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October 2001

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The Planetarium Revolution

Review: JMI's Spicy Split-Ring Scope

A Photo Tour of Africa's Eclipse

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MEADE LX200

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With their large object databases, fast slewing speeds, and uncanny pointing precision, Meade LX200's are recommended for those amateurs who intend an extensive program of CCD imaging, astrophotography, or deep-space observing.

Superb Optics: With oversize primary mirrors for greater full-field illumination, LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

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8" LX200
Schmidt-Cassegrain
$2295

9-Speed Dual-Axis Electronics: Electronics that cover every contingency of telescope positioning — from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, plus 6 other dual-axis drive speeds in between.

Rigid LX200 Dual-Tine Fork Mountings with Dual 5.75" Worm Gears are the choice of advanced observers, CCD imagers, and astrophotographers for their most sensitive applications.

Full Long-Exposure Capability: Meade LX200's have been the instruments of choice in **thousands** of the most detailed long-exposure images ever taken by amateur astronomers.

Strong Field Tripods: Every LX200 includes a fully adjustable steel field tripod perfectly suited to the sub-arc-second resolution of the telescope's optics.

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125. Prices shown are suggested U.S. mail-order retail prices.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 × 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

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12" LX200
Schmidt-Cassegrain
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7" LX200
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PER PLÖSSL 9.7mm
PLÖSSL 12.4mm
PLÖSSL 15mm
PER PLÖSSL 20mm
SUPER PLÖSSL 26mm
SUPER PLÖSSL 32mm
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Extended through October 15, 2001

Buy a Meade LX200 Schmidt-Cassegrain between May 15, 2001 and October 15, 2001 and receive a full set of Meade SP 6.4, 9.7, 12.4, 15, 20, 32, and 40mm eyepieces — plus the SP26mm included as standard equipment with every LX200 — free of charge.

Now you can buy a Meade 7", 8", 10", or 12" LX200 Schmidt-Cassegrain telescope — the largest-selling serious telescopes in the world — **and receive a full set of Meade premium-grade Super Plössl eyepieces absolutely free!** Purchased separately, these eyepieces sell for $599.65.

Designed and manufactured to utilize the very latest in optical glasses, Meade Super Plössls deliver wide 52° apparent fields (44° for the SP40mm) with all the resolution, edge-of-field image sharpness, and color correction demanded in the most advanced visual applications. All eyepieces are multi-coated and include soft rubber eyeguards. In combination with the diffraction-limited optics of a Meade LX200, use the Super Plössls at eight magnification levels to observe hairline lunar and planetary detail, split close binary stars, or study tenuous structure in faint nebulae and galaxies.

Each Super Plössl eyepiece is packed in an individual thread-on poly container to keep the eyepiece clean and secure for long-term storage.

How to Order

1. Buy a Meade 7", 8", 10", or 12" LX200 telescope from any authorized Meade dealer in the U.S.A. between May 15, 2001 and October 15, 2001. (See opposite page for specifications.)

2. Fax or mail a copy of your dealer's invoice (showing the telescope's serial number) to Meade Instruments/Attn: Customer Service, and request the "Free $600 Eyepiece Offer." *Requests for this special eyepiece offer must be postmarked not later than October 31, 2001, and must include your complete shipping address and phone number.*

3. We will ship your free eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed. This special offer is valid only for new LX200 telescopes ordered and received within the U.S.A.

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Orders: 800-422-7876; Info.: 405-364-0858.

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OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

EFSTONSCIENCE, Toronto, Ontario, Canada
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

October 2001 • Vol. 29, No. 10

Astronomy®

COVER ILLUSTRATION: Andrew C. Stewart

FEATURES

34 **Diving for Spacecraft**
Nearly 40 years after Gus Grissom's Mercury spacecraft ended up on the bottom of the Atlantic, intrepid explorers found and recovered it. *Paul Perry*

COVER
42 **Heart of Darkness**
A black hole with more than a million times the mass of the sun wreaks havoc and triggers starbirth in the heart of our galaxy. *Robert Zimmerman*

48 **Eclipse Chasers on Safari**
More than three minutes of fiery prominences and a pearly white corona punctuated an incredible journey to southern Africa. *Bonnie Gordon and Richard Talcott*

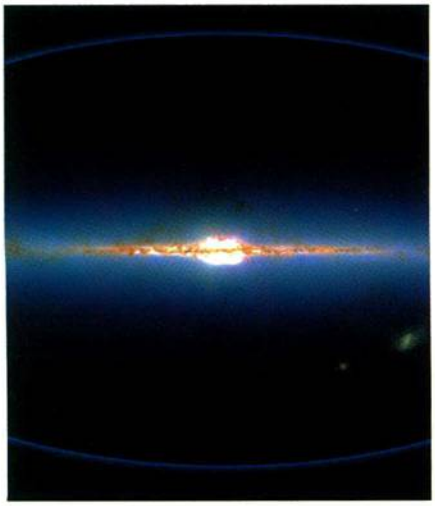
68 **The Next Generation**
The new 6-inch Newtonian reflector from Jim's Mobile, Inc. proves to be a nearly ideal instrument for seeing planetary detail and brighter deep-sky objects. *Phil Harrington*

72 **Celestial Portraits: Sagitta, Delphinus, and Vulpecula**
Dazzling star clusters and a gorgeous planetary nebula make this trio of small autumn constellations fertile ground for backyard observers. *Tom Polakis*

78 **The Planetarium Revolution**
As digital technology works its way down to planetariums, wide-eyed visitors are experiencing the universe in entirely novel ways. *Martin Ratcliffe*

68 JMI's Split-Ring Scope
William Zuback

48 A Photo Tour of Africa's Eclipse
Petter Sutter



84 Ask Astro
2MASS/UMASS/Caltech/IPAC

DEPARTMENTS

6 Behind the Scenes
- Eclipsing Africa

12 Talking Back

20 AstroNews
- A Planetary System Like Our Own?
- Seeing a Black Hole's Edge
- Big Fish in the Kuiper Belt?
- Walking among Baby Giants
- How to Make a Brown Dwarf
- Breaking Up Is Easy to Do

56 Sky Show
- Saturn and Jupiter steal the show as midnight approaches, while a pair of comets highlight the predawn sky. *Martin Ratcliffe and Alister Ling*

84 Ask Astro

88 Strange Universe

90 Star Stuff

Products
- New Coating Technology
- Professional Wireless Weather Station
- nFOCUS Motor Controller

Books
- *SPUTNIK: The Shock of the Century*
- *Observing the Moon*
- *The Planet Observer's Handbook, 2nd Edition*
- *Stars and Planets*
- *A Field Guide to the Stars and Planets, 4th Edition*

98 Looking Ahead

105 Advertiser Index

107 Hot Shots
- Eclipse Memories

112 Ultimate Exposure

78 The Planetarium Revolution

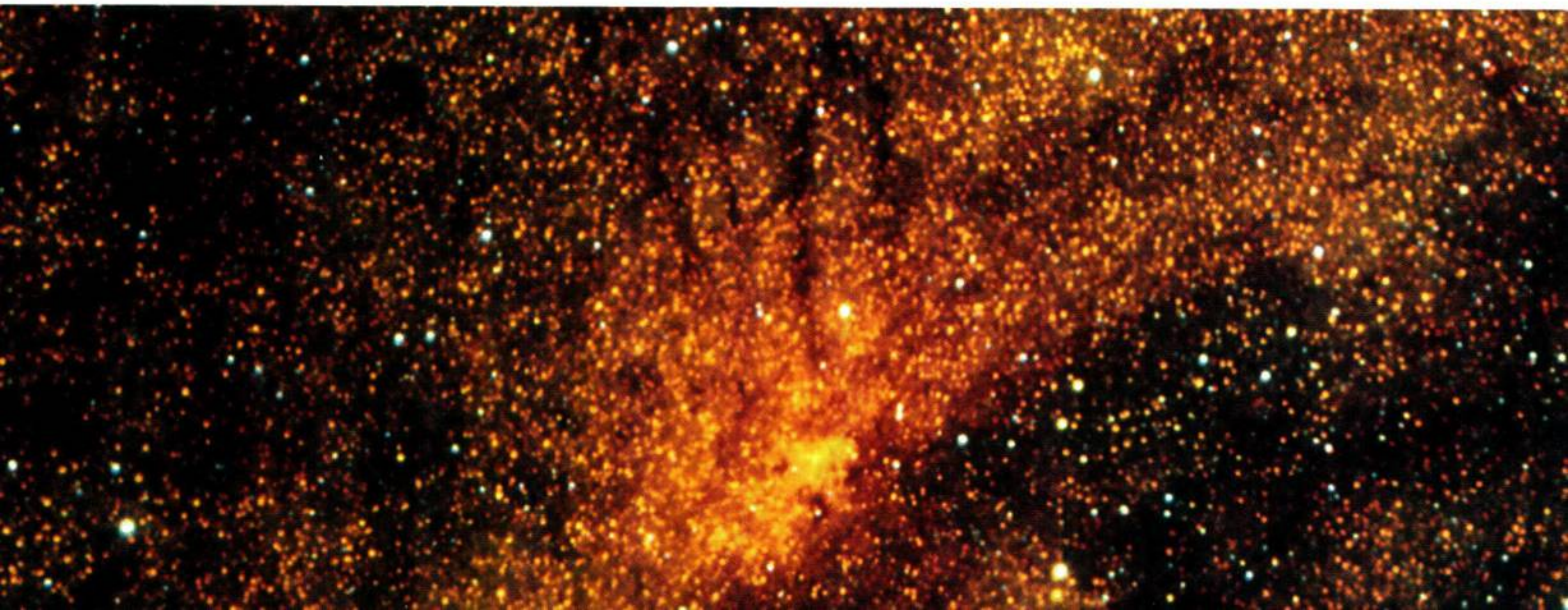
Adler Planetarium

34 Underwater Rescuers Find the Mercury Spacecraft Discovery Channel (DC)

72 Celestial Portraits

From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

42 Face to Face with a Black Hole Ian Gatley



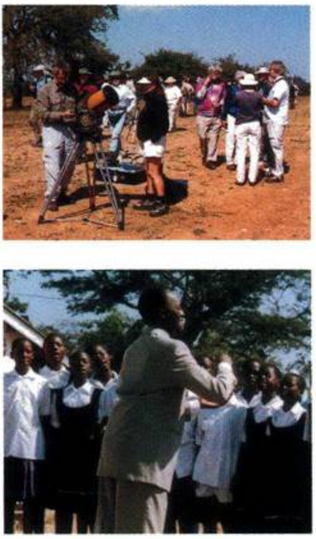
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Eclipsing Africa

As we were planning our trip to Zimbabwe for the June 21, 2001 eclipse, news from the country grew more negative each day. Political unrest had been on the front page in the international news for more than a year. Veterans of the War for Independence, which in 1980 established Zimbabwe as a nation, had become aggressive in their suit for land. Many of them had begun squatting on the largest commercial farms of the country, putting about half the arable land out of production by 2001.

As the result of political actions and urban demonstrations, tourists were being warned off the place. The economy continued to weaken and unemployment was high, which led to reports of crimes against property. The tour books and websites alerted visitors to stay inside after dark. In addition, the southern parts of Africa require a hefty range of inoculations, and HIV infection is rampant throughout the region.



Evelyn Talcott

Susan Tomley

In Rushinga, Zimbabwe, travelers prepare for the eclipse (top) following a performance by the village school choir.

Everything I read made me increasingly nervous about this trip, but I had also heard wonderful things from friends about Zimbabwe, the garden country, best suited of all Africa for touring and safaris. Friends said they had had good journeys, great food, and gregarious, pleasant hosts. The promise of wild animals and perfect eclipse weather kept me packing and getting those shots, but I left with trepidation.

I would soon discover how wrong I was to believe everything I read, to not fully embrace this trip. (So were those folks who ended up shrinking from the adventure completely.) The surprise of Zimbabwe's beauty was astonishing, nothing less. The adventures were rich. We arrived in the capital city of Harare on June 12 and a bus carried us into the city. We obviously were something of an attraction to the pedestrians on the roads. They stared at us as if they had not seen a busload of foreign tourists in a long time. We were welcomed in Harare by guides from Wild Ways, a polished in-country travel company whose staff members organized us into eight small groups that spread out to various safari camps, archeological ruins, and natural wonders such as Victoria Falls and the famous balancing rock formations.

We met up again in Harare on June 20 and took buses early on June 21 to the village of Rushinga to watch the eclipse. The only foreigners who watched from this small dirt airstrip, we were welcomed into town by at least 1,000 villagers, many of whom sang for us and then exchanged addresses with us for future correspondence. Villagers watched the eclipse with us, using extra solar viewers we had brought. To learn more about the eclipse in Africa and to see some breathtaking photos, turn to our eclipse story on page 48 and to Hot Shots on page 107.

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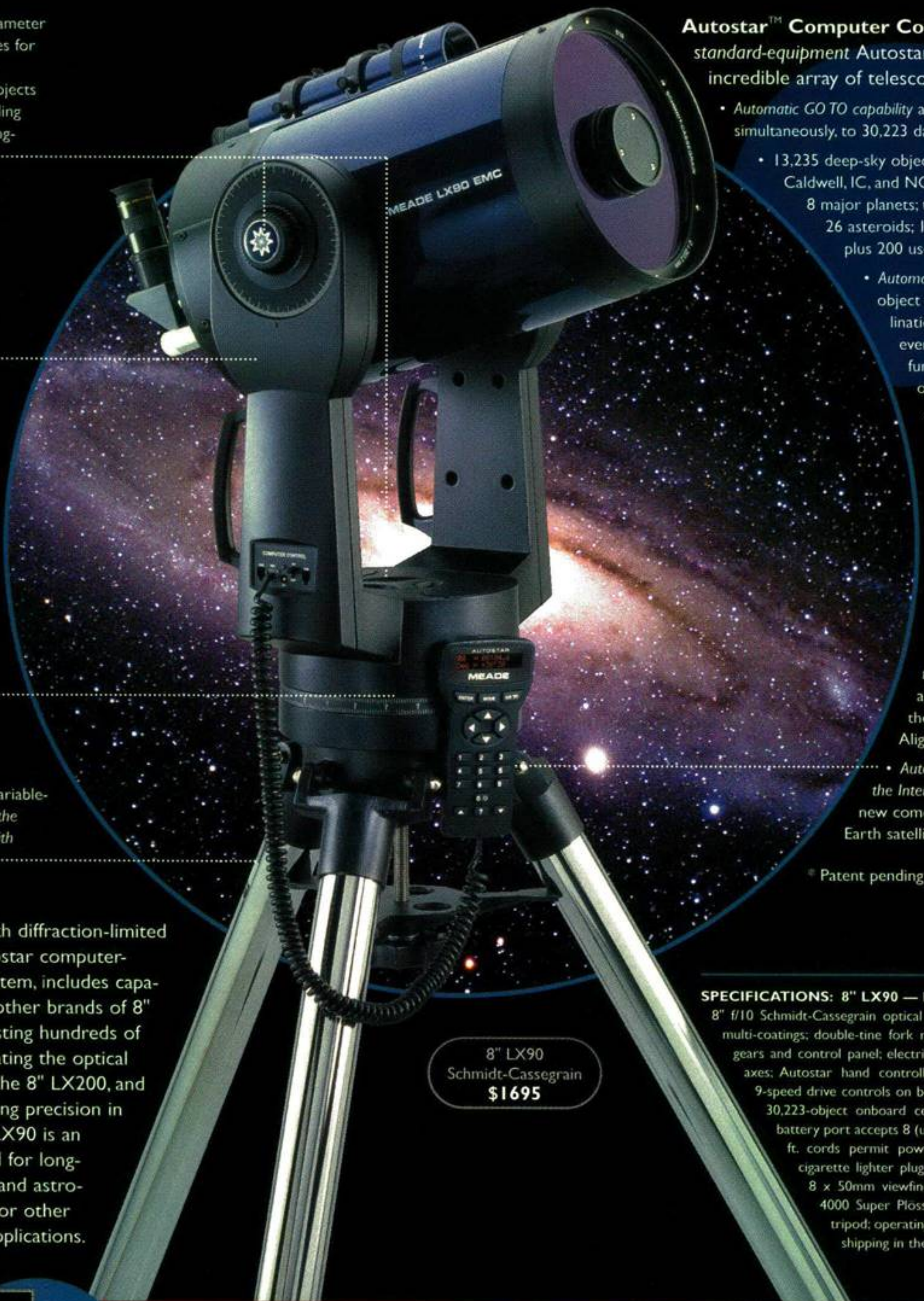
LX90

MEADE®

8" LX90

THE TELESCOPE OF A LIFETIME



Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered by C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200 models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to any object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align®.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

® Patent pending

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system and coatings of the 8" LX200, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is an instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; operating instructions. **$1695**. Packing & shipping in the 48 states: $95.

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Each complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, premium-grade Pyrex® optical system, and precision, heavy-duty equatorial mount with DC-powered drive system for fully automatic tracking.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Meade® Starfinder™ 8" Equatorial with Motor Drive... *now only* **$599!**

Shown with optional #2011 Magellan I Computer System

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec.

#2011: for Meade Starfinder Equatorial 6", 8", or 10"..... $295.

#2012: for Meade Starfinder Equatorial 16"............... 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/ microslewing system.

#2018: for Starfinder Equatorial 6", 8", 10".....495.

#2019: for Starfinder Equatorial 16"............595.

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

6" f/8 **$499**

8" f/6 **$599**

10" f/4.5 **$699**

16" f/4.5 **$2695**

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

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Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

To Order any Starfinder model: contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.

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LX10

MEADE 8" LX10

NOW WITH FREE FIELD TRIPOD FOR A LIMITED TIME!

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as the more expensive Meade 8" LX200.

Series 4000 Super Plössl 26mm eyepiece: An $80 eyepiece, the SP26mm complements the exquisite imaging of Meade 8" Schmidt-Cassegrain optics.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power visual applications of the telescope, or for photographic or CCD imaging.

Cordless, DC-Powered Electronic Motor Drive: With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered for 50 hours by four AA-size batteries that fit conveniently into the telescope's control panel.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope in R.A. at 2x speed during long-exposure astrophotography. With the optional electric Declination motor *(see below)* added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

LX10 Field Tripod: The chromed steel LX10 Field Tripod provides an extremely rigid platform for visual and photographic observations with the telescope. Regularly $195, this tripod is included **free of charge** for a limited time with your purchase of the 8" LX10 telescope.

This free offer is valid at participating Meade dealers in the U.S.A. and may be cancelled without notice at any time.

Limited time offer! $195 LX10 Field Tripod FREE!

8" LX10 Schmidt-Cassegrain **$995**

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 × 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; LX10 Field Tripod (included only for a limited time, as noted above); complete operating instructions.

$995. (+ $65 packing & shipping in the 48 states)

Electric Declination Motor System for LX10	**95.**
#2014 Magellan I Telescope Computer System for LX10 with 12,218-object database	**375.**

Prices shown are suggested U.S. mail-order prices

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Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

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6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™
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67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle, 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

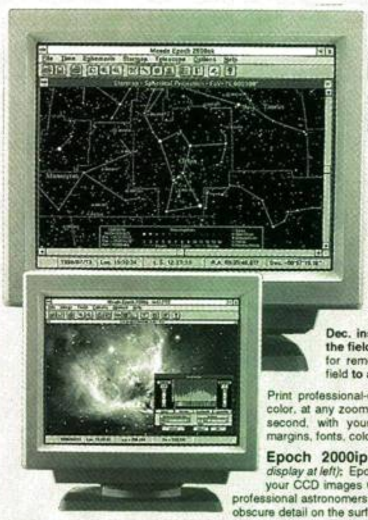
#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-10; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644
MEADE
FLIP-MIRROR SYSTEM

#647
MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$149**
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LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk	**25**
EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$199**

f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated: 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

#932 45° Erecting Prism for ETX®

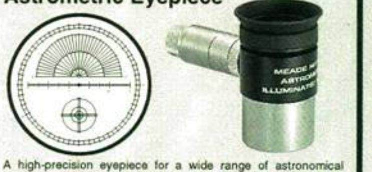
For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70	**$19.95**
#673 for ETX-90	**24.95**
#675 for ETX-105	**27.95**
#678 for ETX-125	**29.95**

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, *etc.* Includes steel latches & key.

#774 Case for ETX-90 models: **99.95** (8.58)

#776 Case for ETX-105EC: **99.95** (8.58)

#775 for ETX-125EC: **149.95** (13.38)

Advanced Field Tripod for ETX-125

#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

#889 Adapter: **$69.95** (7.70)

ETX® Deluxe Field Tripod

#883: Designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 34" to 54", for seated or standing observations. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **$199.95** (10.00)

#772 Carry Bag for Deluxe Field Tripod

Custom-fitted Cordura-type bag permits easy portability and storage of the #883 Tripod, above. Includes carry strap, accessory pockets. **$49.95** (6.40)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with any ETX model. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus ETX/EC models through the telescope's hand controller.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:

$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:

$119.95 (6.85)

ELECTRONIC CONTROLLER
MEADE

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

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Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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This Diamond Ring

I was in Chirundu, Zimbabwe, to witness the total solar eclipse in June, when I ran into Andrea Bassing and Steve Matney of Hyattsville, Maryland.

On the spur of the moment, they decided that a solar eclipse was also the perfect setting for a wedding. A Zimbabwean Justice of the Peace married the couple 15 minutes before totality. Members of our expedition served as maid-of-honor and best man.

Andrea was born in Africa when her parents were in the Peace Corps, and Steve has been reading *Astronomy* magazine since his teens. After the eclipse, the couple honeymooned in South Africa.

I bet no one can top that bride's diamond ring. — *Tony Galván III, Goleta, California*

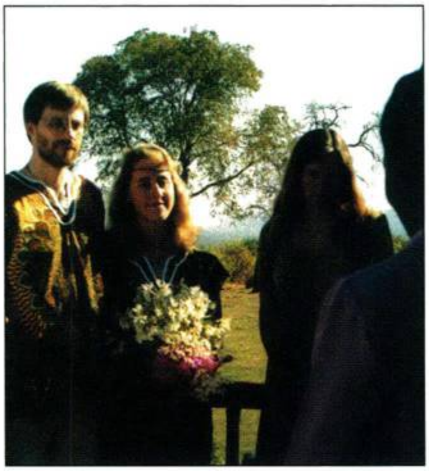
Solar Eclipse/Solstice/Equinox

When was the last time an eclipse and a solstice or an equinox occurred on the same day, or within 24 hours of each other? — *Lynn Palmer, San Francisco, California*

It was June 20, 1974 when totality's shadow grazed the Southern Hemisphere within 24 hours of a solstice, passing over Cape Leeuwin, Australia, on the southwest end of the continent. The last such annular solar eclipse occurred September 23, 1987, in the Northern Hemisphere, over Pinyao, China.

You'll have to wait until March 20, 2015 for an equinox-related total eclipse, which falls mostly over the North Atlantic and Arctic Oceans. If you're just north of Denmark's Faeroe Islands, you'll get a brief (two-minute, 47-second) land-based view of this event, weather permitting.

Expect the next annular eclipse on a solstice or equinox to pass over South America (specifically, the northern halves of Guyana, Suriname, and French Guiana) on September 22, 2006. — Astronomy *editors*



Steve Matney and Andrea Bassing celebrated June's eclipse by exchanging vows. *Tony Galván III*

Gaseous Planet

In his May 2001 "Strange Universe," Bob Berman perpetuated a common misconception. He stated, "... Jupiter's atmosphere smells rife with methane (swamp gas) and ammonia." Jupiter's atmosphere undoubtedly smells — but not because of methane.

Methane is a colorless, odorless, tasteless gas. This is why natural gas (primarily methane) supplied to homes is odorized — so leaks can be more easily detected.

Swamp gas, along with landfill gas and digester gas, is primarily methane. However, its odors arise from the "witch's brew" of sulfur-containing compounds created by inorganic decomposition, not because of methane. — *William Andrews, Pasadena, California*

Gimmicky Cosmology

I found the reference to superheroes ("Inside-Out Cosmology, June, 2001) insulting, distracting, and of no significance to the rest of the article.

Does author Robert Zimmerman think that we won't be interested in this subject without a gimmick? Give us more credit, please. — *George Goodwin, Hull, Massachusetts*

Thanks for devoting the entire June 2001 issue to cosmology. Robert Zimmerman's article is especially fascinating when he compares and merges cosmology with particle physics. While I'm indebted to him for his thorough description of subatomic particles, I'm wondering how anyone keeps them all straight.

We've come a long way since the 1950s, when our (private school) teachers slapped our fingers with a yardstick if we chose to believe in an expanding universe. It's a good thing some of us slept through science back then. — *Cami Goodmanson, Roseville, Minnesota*

Eyepieces Key to Viewing

Astronomy's images are excellent. However, those that I see through my 8-inch Dobsonian reflector are not. Using the eyepiece that came with my scope, Mars appears only about 1/8 inch across. How can I improve the view? — *David A. Hubble, Lewiston, Idaho*

It's sad but true that telescope views are often inferior to published astrophotos. Before the marriage of the camera to the telescope, the universe was populated by vague smudges of light that astronomers universally called "nebulae," simply because they could not resolve fine detail. Therein lies the beauty and great wealth of astrophotography: Film and CCDs (charge-coupled devices) record objects with far greater resolution than the human eye. We now know many of these nebulae are entangled clouds of interstellar gas and dust, while others are incredibly distant galaxies, each holding millions, billions, or even trillions of stars.

But whether or not you are into astrophotography, you'll want to get the most from your telescope. For starters, understand that no single eyepiece is suitable for everything. Expand your

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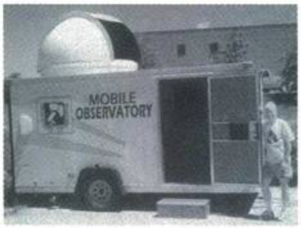

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Become an astronomical observer, not a peeker. I recommend taking notes, and — better still — making a drawing of each object. Keep those observations in a special notebook. The trained human eye has such a tremendous dynamic range that you will actually see details missed in the photographs before you know it. — Phil Harrington, Brookhaven National Laboratory

Opposing Mathematical Universes

I am struck by *Astronomy*'s use of the English system for distances, weights, etc. Although you are based in and most of your readership is from the United States, I am still perplexed that a science magazine would not prefer the SI (System International) units for measurement. — *Tjeerd van Hoytema, The Netherlands*

Thanks for using English measurements in *Astronomy*. To say an asteroid is 50 km across means nothing to me, but I can visualize a 10-mile asteroid. — *Russell Perkins, Concord, New Hampshire*

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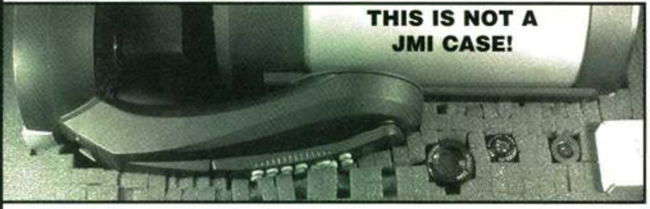

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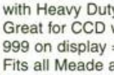

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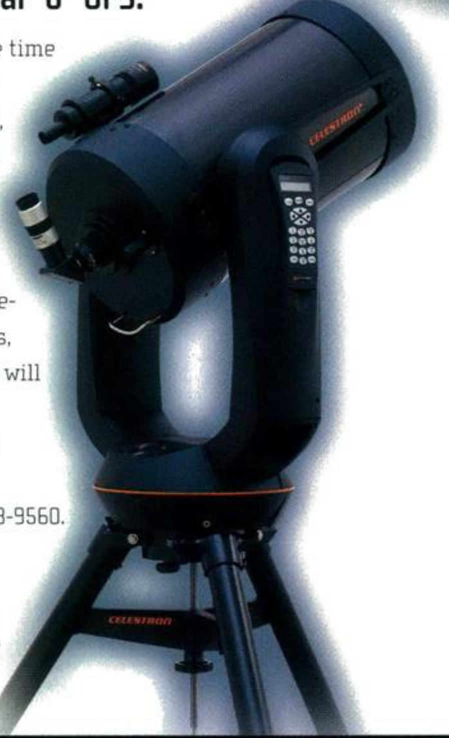

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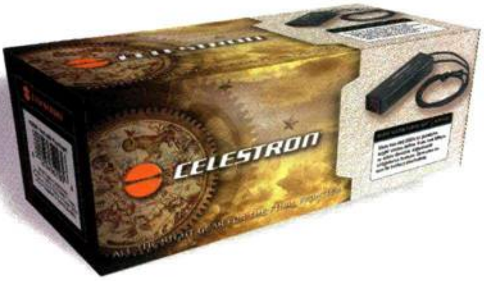

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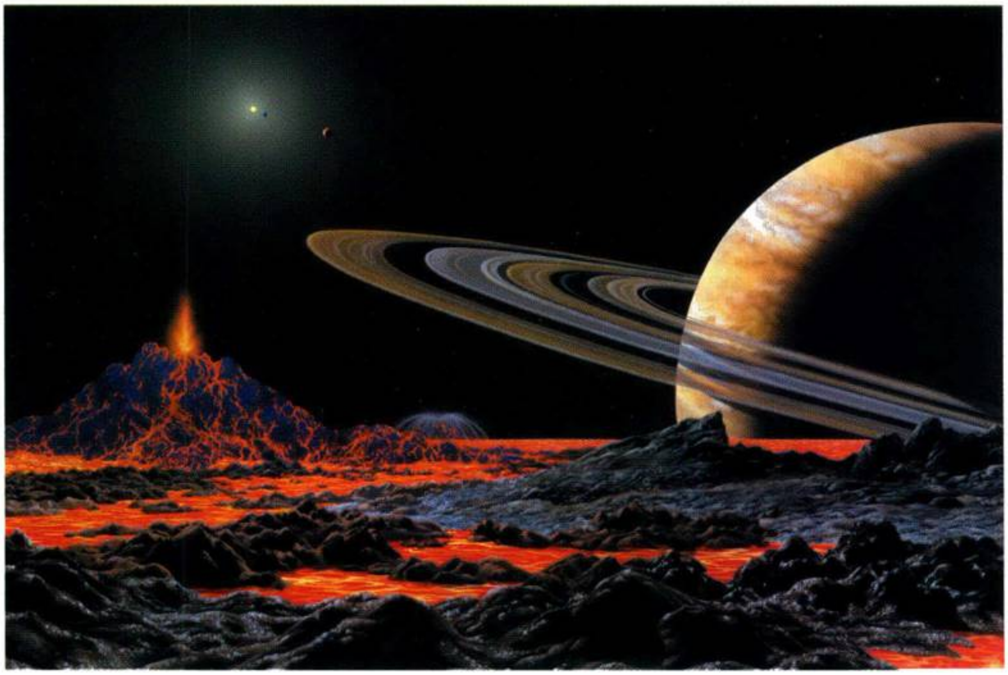
Lynette Cook

A newly discovered system of planets around 47 Ursae Majoris could be similar to ours. This view is from a hypothetical moon of that system's outer giant planet.

▶ The planet-hunting team led by Geoff Marcy and Paul Butler has done it again. The team had previously found about 40 extrasolar planets, including three systems with multiple planets. But just when it seemed that new discoveries could barely elicit a yawn, the team found a system unlike any other in its collection. What makes the system interesting is that the only planetary system it resembles is our own. It boasts two Jupiter-class planets, both in circular orbits.

The two planets orbit 47 Ursae Majoris, a near twin to the sun located 46 light-years away. The inner planet, which Marcy and Butler discovered in January 1996, has a mass of at least 2.6 Jupiters and orbits the star at a distance of 2.1 astronomical units (AU; one AU is the distance between the sun and Earth). That would put it just beyond Mars in our solar system.

The newly discovered planet has a minimum mass of 0.76 Jupiter, so the two planets have about the same mass ratio as Jupiter and Saturn. The lighter planet orbits farther out, at a distance of 3.7 AU, which would place it in our solar system's asteroid belt.

"Except for 47 Ursae Majoris, every extrasolar planet that has been discovered has been disturbingly unusual in comparison with our own solar system," says Debra Fischer of the University of California at Berkeley. Fischer, a member of Marcy and Butler's team, discovered the outer planet after collecting several more years of data on 47 Ursae Majoris with the 3-meter Shane Telescope at Lick Observatory in California.

Most of the extrasolar planets discovered to date follow elongated orbits averaging between 0.2 and 3 AU from their central star, while the rest are mired in searing-hot orbits less than 0.1 AU from their sun. Astronomers think these planets formed farther out and later migrated inward either gradually or in violent gravitational scattering events with neighboring planets. In either scenario, minuscule terrestrial planets would either be thrown into the star or cast adrift into interstellar space.

"Now, for the first time, we have a system that looks like it had a gentle dynamical history, similar to our own solar system," says Fischer.

Shortly after discovering the gravitational wobble of 47 Ursae Majoris induced by the gravity of the second planet, Fischer contacted Greg Laughlin, a theorist at NASA's Ames Research Center. Laughlin's computer simulations show that the gravity of the large inner planet would jostle planetesimals in the star's habitable zone, preventing them from aggregating into a terrestrial planet.

Laughlin also wonders how the two big boys formed in the first place. "This system was somehow at least four times more efficient than our solar system at gathering up material to build planets. Yet the orbits suggest that the planets did not migrate inward very much. How then did the system put together a behemoth of a planet in what was presumably an ice-free region, which in our own system gave rise only to asteroids? We don't know."

While this system might not offer prime real estate for life, Fischer notes that the discovery is good news for astrobiologists. "We have studied only about 20 stars with enough sensitivity and for sufficiently long time periods to detect the outer planet around 47 Ursae Majoris. In the next few years we will learn if solar system analogs are rare."

— Robert Naeye, Astronomical Society of the Pacific

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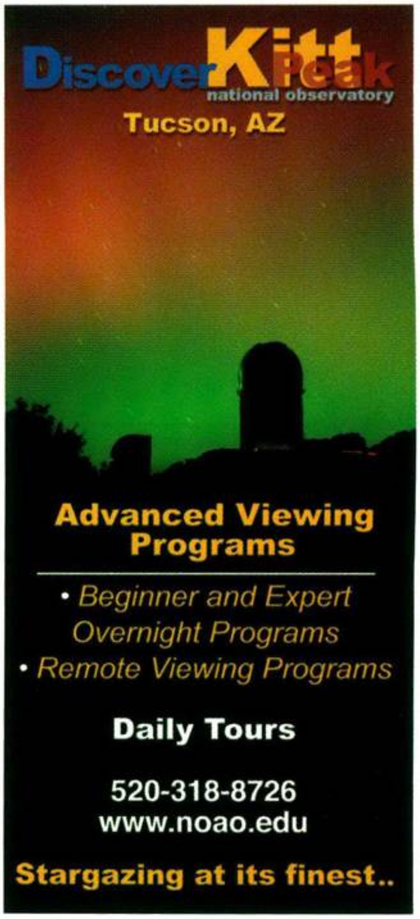

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BLACK HOLES

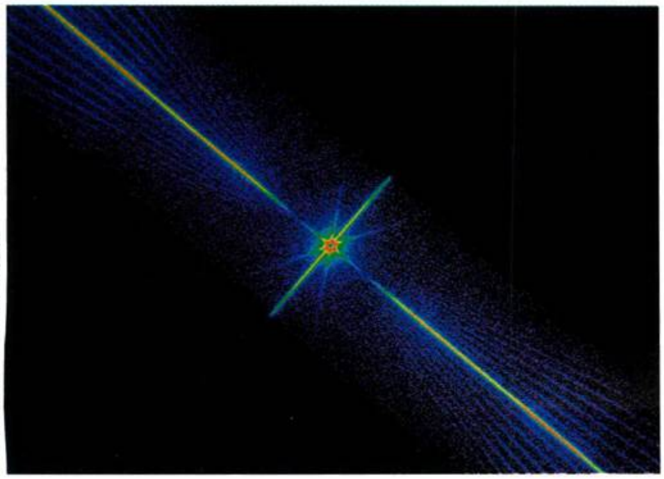
Seeing a Black Hole's Edge

▶ Using a quartet of orbiting space telescopes, astronomers have peered deep inside the immediate surroundings of a black hole and — to their surprise — found nothing. They had expected to see a disk of material nearly butting up against the black hole's surface, but instead found it lurking more than 20 times farther away.

Contrary to popular belief, black holes are not necessarily the darkest objects in the universe. If a companion star feeds material onto a black hole, the incoming gas will form a disk before it spirals into oblivion. Friction within this accretion disk can heat the gas to millions of degrees, causing it to glow brightly.

Most astronomers think that the accretion disk will reach to within about 25 miles (40 kilometers) of the event horizon — the "surface" of the black hole that marks the boundary beyond which nothing can ever escape — if material flows toward a black hole at a high rate. But they disagree over how close the accretion disk will come with a low transfer rate.

Chandra captured a black hole's spectrum (the bright yellow and orange stripe), revealing that its accretion disk stops farther out than predicted. (The spokes and faint diagonal rays are artifacts.)



NASA/CfA/J. McClintock and M. Garcia

The perfect test subject was discovered in March 2000, when the Rossi X-ray Timing Explorer (RXTE) detected a sudden eruption of high-energy x rays from a spot in the constellation Ursa Major. Dubbed XTE J1118+480, the object lies 5,000 light-years from Earth and consists of a black hole with about seven times the mass of the sun locked in a tight orbit with a sunlike star. (The event horizon for such a black hole would have a radius of some 13 miles, or 21 km.)

Because Ursa Major lies well away from the plane of the Milky Way, there's little gas and dust in that direction to absorb radiation. An international team of astronomers was able to target XTE J1118+480 with an array of orbiting observatories: The Hubble Space Telescope and Extreme Ultraviolet Explorer observed the object's ultraviolet radiation; RXTE continued focusing on high-energy x rays; and the Chandra X-ray Observatory provided a link between the two by looking at low-energy x rays.

"The Chandra data indicate that this accretion disk gets no closer to the

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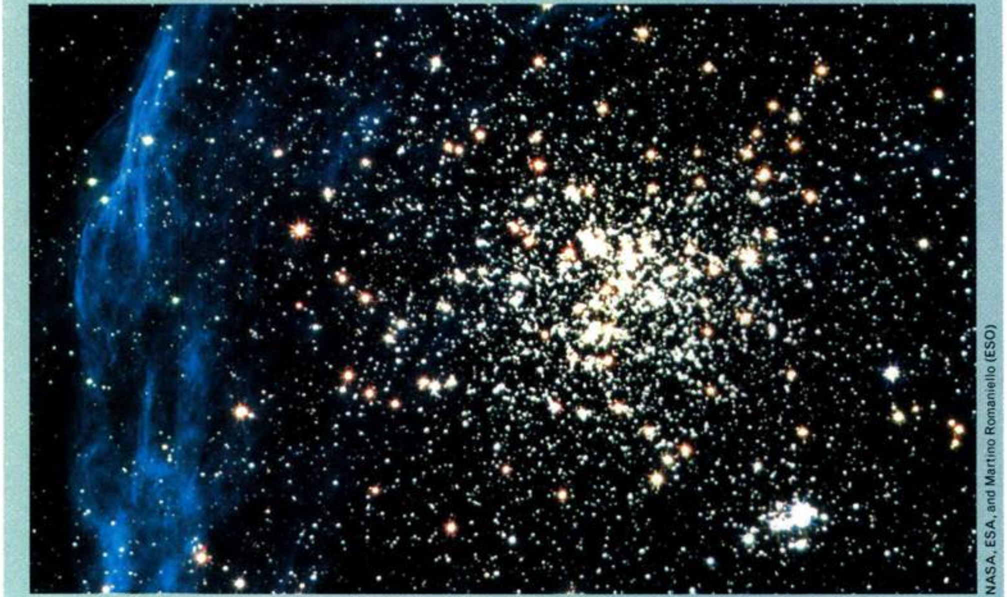

NASA, ESA, and Martino Romaniello (ESO)

THIS YOUNG, MASSIVE STAR CLUSTER appears unlike any seen in our galaxy. NGC 1850 lies in the Large Magellanic Cloud (LMC), a satellite of the Milky Way, and consists of two clusters. But it's the large, bright cluster at the center of this Hubble image that intrigues astronomers. It looks for all the world like a globular star cluster — big, massive, and spherical — though it's only some 50 million years old. (All globulars in the Milky Way are ancient, roughly 10 billion years old.) The blue filaments to the left are the remains of an early generation of stars that exploded as supernovae. The smaller cluster at lower right is only 4 million years old and contains lots of hot, blue stars as well as fainter red stars still in the process of settling down.

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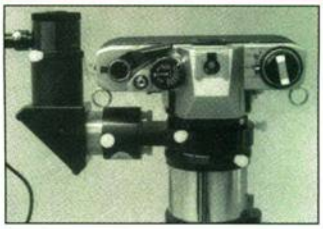

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event horizon than about 600 miles, a far cry from the 25 miles that some had expected," says Jeffrey McClintock of the Harvard-Smithsonian Center for Astrophysics, who led the Chandra observations. The researchers hope that the new observations will help provide a better understanding of how energy gets released as it spirals into a black hole. But for now, says team member Ann Esin of Caltech, "This presents a fundamental problem for models in which the accretion disk extends close to the event horizon."

— Richard Talcott

PLANETARY SCIENCE

Big Fish in the Kuiper Belt?

Since Pluto's discovery in 1930, astronomers have been waiting like steadfast fishermen to see if they can get a nibble from something just a little bigger. And although the astronomical equivalent of a 100-pound catfish continues to elude them, a team of Lowell Observatory, MIT, and Large Binocular Telescope Observatory astronomers recently discovered that there still might be a few big fish left lurking in the Kuiper Belt. In fact, they've found one Kuiper Belt Object (KBO), called 2001 KX$_{76}$, that may be as large as Pluto's moon Charon.

Extending into the far reaches of the solar system from beyond the orbit of Neptune, the Kuiper Belt is a reserve of icy material left over from the birth of the sun. Until 1992, Pluto and Charon were the sole known inhabitants of the Kuiper Belt. Now, nearly 400 KBOs have been discovered from this reservoir, which some think may contain thousands of 100-km sized objects and billions of 10-km sized objects.

The big Kuiper Belt Object 2001 KX$_{76}$ appears as a pair of red-cyan dots on this discovery image.

Deep Ecliptic Survey Team/NOAO/AURA/NSF

Although high in number, the combined mass of the Kuiper Belt's inhabitants likely wouldn't amount to more than 10 percent of Earth's mass. Nonetheless, every KBO is worth its weight in gold to astronomers. Pristine relics from the dawn of the solar system, KBOs contain valuable information about the formation and evolution of the sun and planets.

Researchers discovered 2001 KX$_{76}$ last spring with the National Optical Astronomy Observatories' 4-meter Blanco Telescope in Chile, hard on the heels of another KBO discovery earlier in the year. That object, now dubbed Varuna, is believed to have a diameter of roughly 550 miles (900 km), based on assumptions of its surface reflectivity, or albedo. By comparison, Charon's diameter is about 750 miles (1,200 km).

With the idea that the brightness of an object can be determined from its surface area and albedo, astronomers can use the brightness of 2001 KX$_{76}$ as an indicator of size. But ultimately, estimating the size of 2001 KX$_{76}$ depends on key assumptions that team leader and Lowell Observatory director Robert Millis and his colleagues make regarding its albedo. If the albedo of 2001 KX$_{76}$ is as high as seven percent — meaning that seven percent of the sunlight striking the object is reflected — then it would have a diameter of 600 miles (960 km). But if the albedo is as low as four percent (comparable to asphalt), its diameter may be 790 miles (1,270 km).

The team's detection of 2001 KX$_{76}$, orbiting the sun at a distance of 4.0 billion miles (6.4 billion km), opens planetary science to the possible existence of an entire population of giant KBOs. "We have every reason to believe that objects ranging up to planets as large or larger than Pluto are out there waiting to be found," explains Millis. "Until the Kuiper Belt has been thoroughly explored, we cannot pretend to really know the extent or the content of the solar system."

— William Schomaker

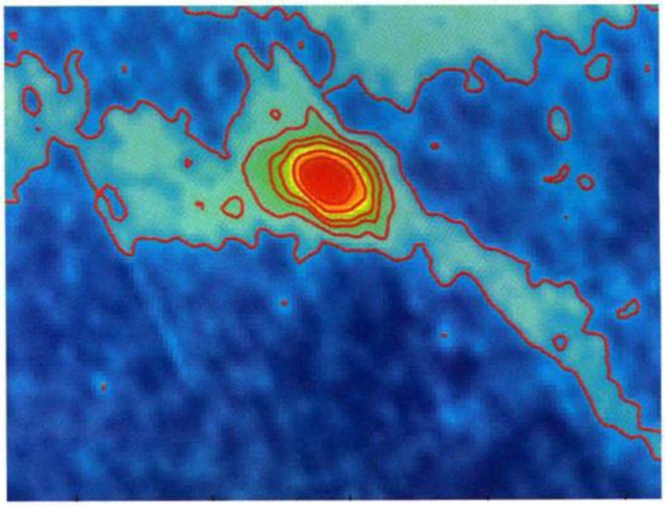
STAR FORMATION

Walking among Baby Giants

Gigantism, as described by the *Encyclopedia Britannica*, is "excessive growth in stature, well beyond the average for an individual's race and environmental conditions." Astronomy has its own form of this condition: overgrown, supermassive stars. How stars get so big remains a topic of heated debate, but one researcher has recently discovered a freakishly large stellar embryo, or protostar, that may help solve some of the riddles.

Astronomers rarely glimpse protostars — large clouds of gas and dust in the process of collapsing into stars. So far, the 30 or so that have been observed appear to be the seeds of garden-variety, low-mass stars.

Göran Sandell, a star-birth investigator and



The yellow and orange oval in this submillimeter map shows the biggest protostar ever seen: a 300-solar-mass disk nearly 300 times the size of the solar system.

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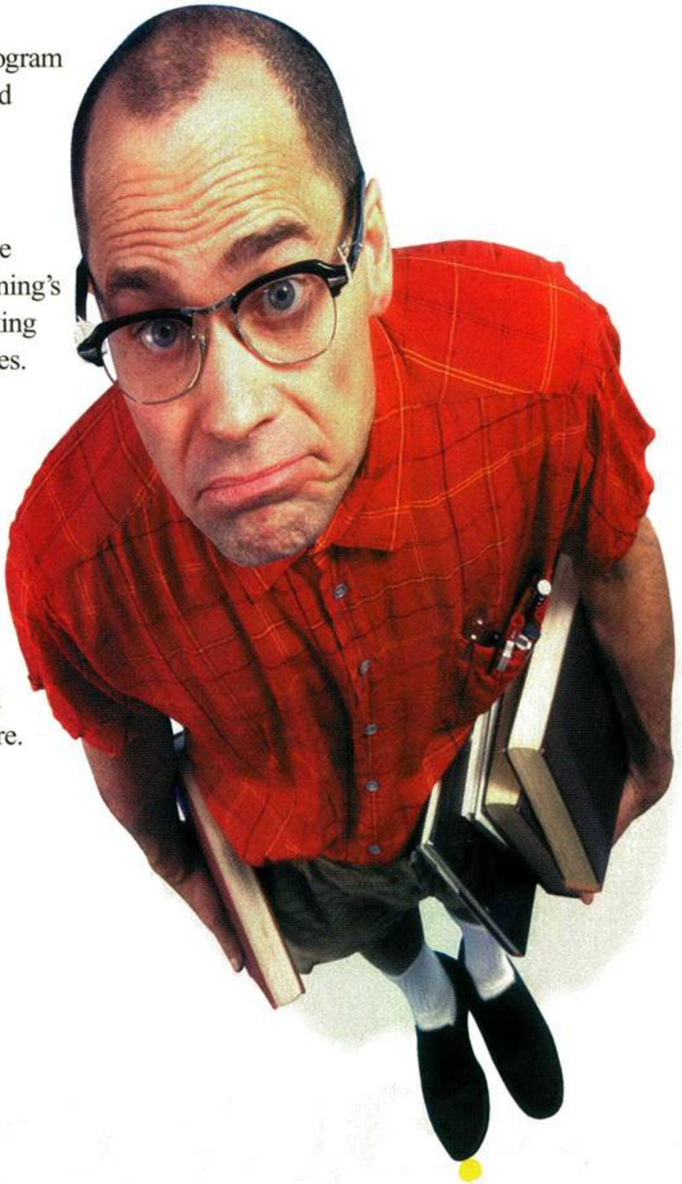

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protostar hunter with the Universities Space Research Association, has spent many years snooping around stellar nurseries. He uncovered the 300-solar-mass protostar tucked away in a huge, dark gas cloud 7,000 light-years from Earth in the constellation Cepheus, near the emission nebula NGC 7538. He reported his findings at the June meeting of the American Astronomical Society in Pasadena, California.

In order to spot the object, dubbed NGC 7538S, Sandel used a specialized camera sensitive to submillimeter radiation, which has a wavelength longer than infrared but shorter than radio, mounted to the 50-foot (15-meter) James Clerk Maxwell Telescope on Hawaii's Mauna Kea. Submillimeter energy easily penetrates the dark, dense molecular clouds that often cloak regions of star creation.

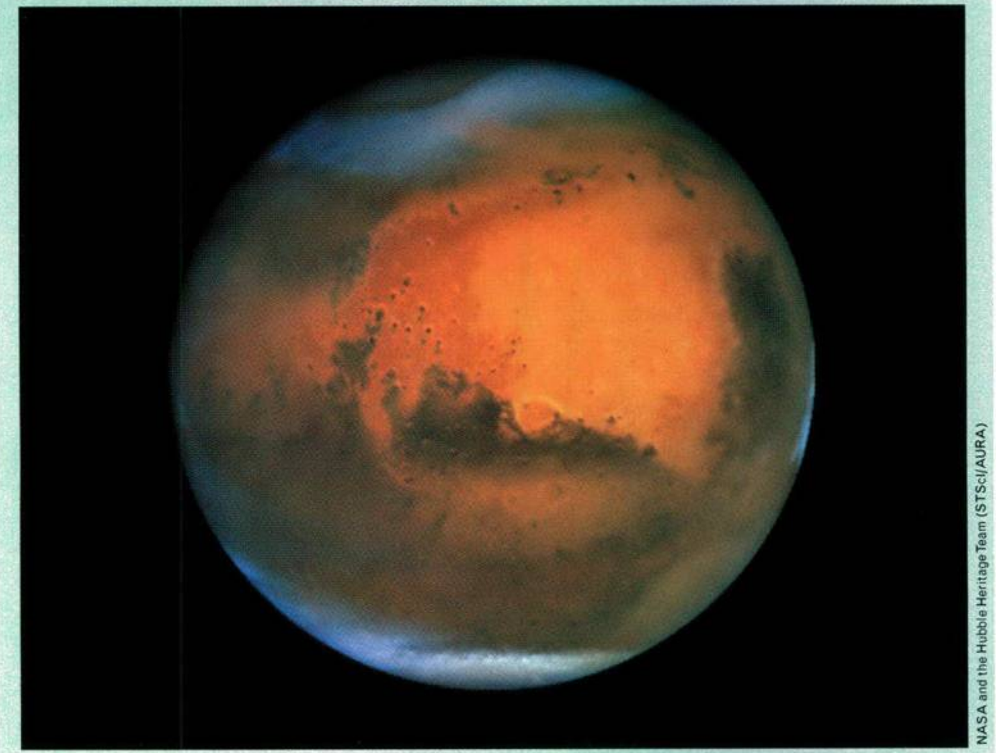
Sandell soon observed a huge disk of gas and dust — nearly 300 times the size of our solar system — within a tight pack of interstellar clouds. He constructed a submillimeter map of NGC 7538S and determined that because of its girth and density, the object is likely gravitationally unstable and on the cusp of collapsing under its own weight.

"All these factors point to only one conclusion," says Sandell. "This object is a protostar, and a big one. It's in the process of forming one or more very massive stars, a process that is very poorly understood."

Sandell is confident that this monster of a protostar will evolve into a single star because he has so far detected only one "maser source." A maser is a stream of amplified microwave radiation analogous to laser light that is emitted from a very compact region. Some scientists think that within hotbeds of star formation, the number of maser sources hints at the eventual number of stars.

The reason so few massive protostars are seen, says Sandell, is that their development into high-mass stars happens in an astronomical blink of an eye — only about 10,000 years. More typical protostars reach maturity as sunlike stars in roughly one million years. — Paul Morledge

HUBBLE SPACE TELESCOPE



NASA and the Hubble Heritage Team (STScI/AURA)

FROSTY POLAR CAPS, water-ice clouds, and dark surface markings highlight the rusty landscape of Mars viewed by Hubble. This image was taken on June 26, 2001, when the Red Planet was 43 million miles (68 million km) from Earth, near its closest approach of the 2001 apparition. Details as small as 10 miles (16 km) across can be seen. A close look reveals several seasonal dust storms. One covers a good portion of the north polar cap (at top) while a smaller one churns nearby. The most impressive, however, is just starting to spill out of the giant Hellas Basin (at lower right). Within a few weeks, this storm grew and intensified, covering more than half the planet.

STAR FORMATION

How to Make a Brown Dwarf

▶ Every litter has its runt. And so it goes with star formation. At least that's what University of Colorado researcher Bo Reipurth and his Cambridge Institute of Astronomy colleague Cathie Clarke would say.

According to the duo, brown dwarfs — wannabe stars that range in mass from 13 to 75 times that of Jupiter — are a natural byproduct of star formation processes rather than the result of rare, idealized conditions. The picture Reipurth and Clarke paint is one in which brown dwarfs are very common. In addition, their recently published theories clarify some long-standing misconceptions about these diminutive objects.

When dense cores of gas and dust reach a critical mass and begin to collapse in the early stages of the star-formation process, individual mass seeds find

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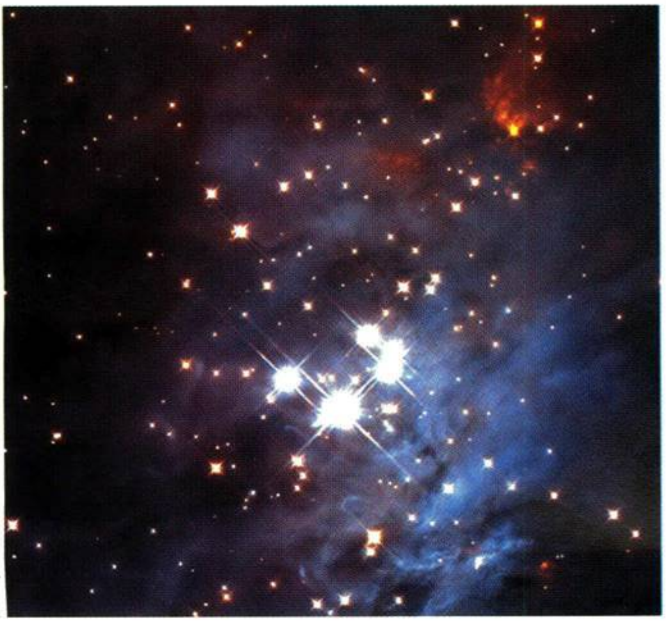
themselves competing with one another for limited star-making resources, much in the same way that a litter of pups compete for their share of their mother's milk. The more material a budding star can accrete, the better chance it will have of reaching the critical mass of about 8 percent the mass of the sun. That's how much bulk is needed to initiate thermonuclear fusion, the critical process that defines a star and keeps it shining.

It turns out that the smaller mass seeds, what Reipurth calls embryos, are constantly being cast about from gravitational interactions with larger seeds. Consequently, mass seeds that start out small have a much harder time gaining mass and are more likely to remain small. What's more, the smallest embryos will often be completely ejected from the star-forming region, destined to spend eternity alone as brown dwarfs.

Astronomers have long wondered why binary systems containing one brown dwarf and one main sequence star are so rare, and why those that do exist have such an enormous separation between the objects. According to Reipurth, these findings are completely consistent with their theories. "Our model can now explain that," says Reipurth, "because a stellar embryo very close to one that succeeds in becoming a star would normally also get sufficiently fed to become a star."

As for the latter case, Reipurth thinks that some brown dwarfs may be kicked out of the star-forming cores, but not quite far enough to escape the pull of at least one of their neighbors, resulting in binary systems with one brown dwarf at a large separation from its stellar companion.

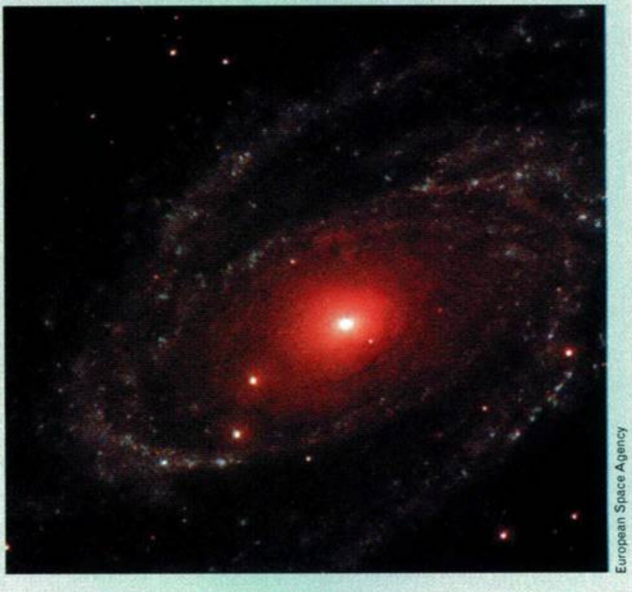
Reipurth and Clarke's findings may also help astronomers to draw the distinction between what some call giant planets and others call brown dwarfs. "Even though brown dwarfs failed in the end to become stars, they still were formed in the same way as stars," explains Reipurth. "In contrast, giant planets are frequently found as very close companions to stars, implying that they grew as planets from circumstellar disks, like planets in our own solar system." — W. S.



A swarm of about 50 newborn brown dwarfs (the fainter dots) populate the Orion Nebula in this Hubble near-infrared image.

NASA/STScI

XMM-NEWTON



European Space Agency

ONE OF THE BRIGHTEST GALAXIES in the northern sky, M81 in Ursa Major, posed for the ultraviolet camera onboard the XMM-Newton satellite. This spiral galaxy lies 12 million light-years from Earth and forms a conspicuous pair with its neighbor, M82. The two galaxies apparently had a close encounter some 10 million years ago, triggering a burst of star formation. The hottest regions in M81 are the stellar nurseries thus created, which churn out hot, massive stars. They appear blue in the image. The coolest regions appear red and concentrate in the galaxy's central bulge, where most stars are older and less massive. (The bright reddish dots are foreground stars in our galaxy.) The bright white point of light at the galaxy's center remains the subject of debate. Some astronomers think it represents an intense starburst region in the core, while others suspect it traces the emission from a supermassive black hole that's slowly accreting gas and stars.

PLANETARY SCIENCE

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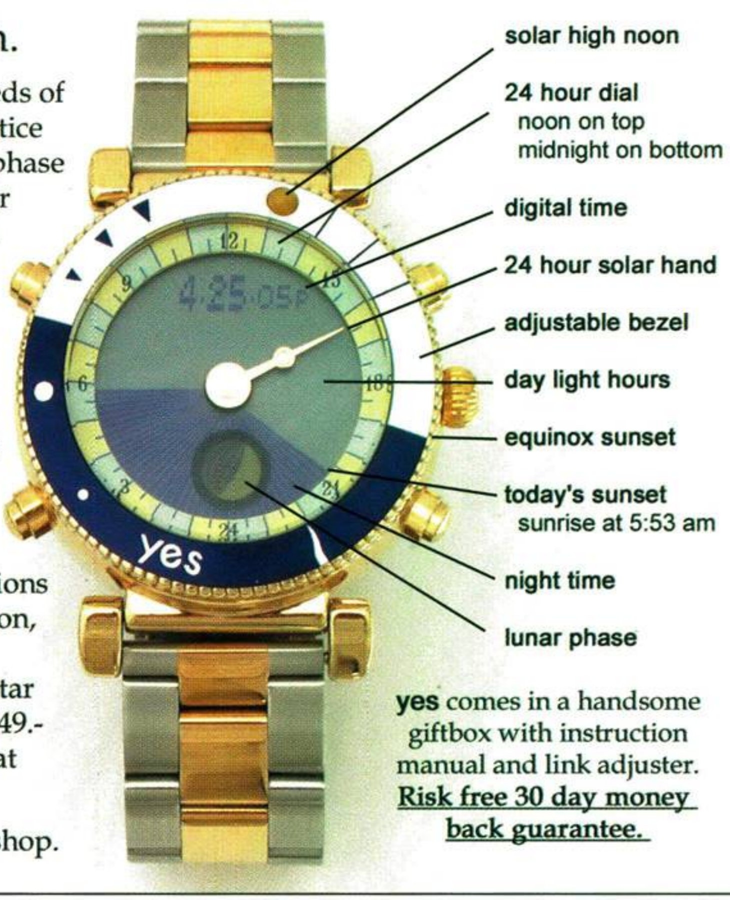

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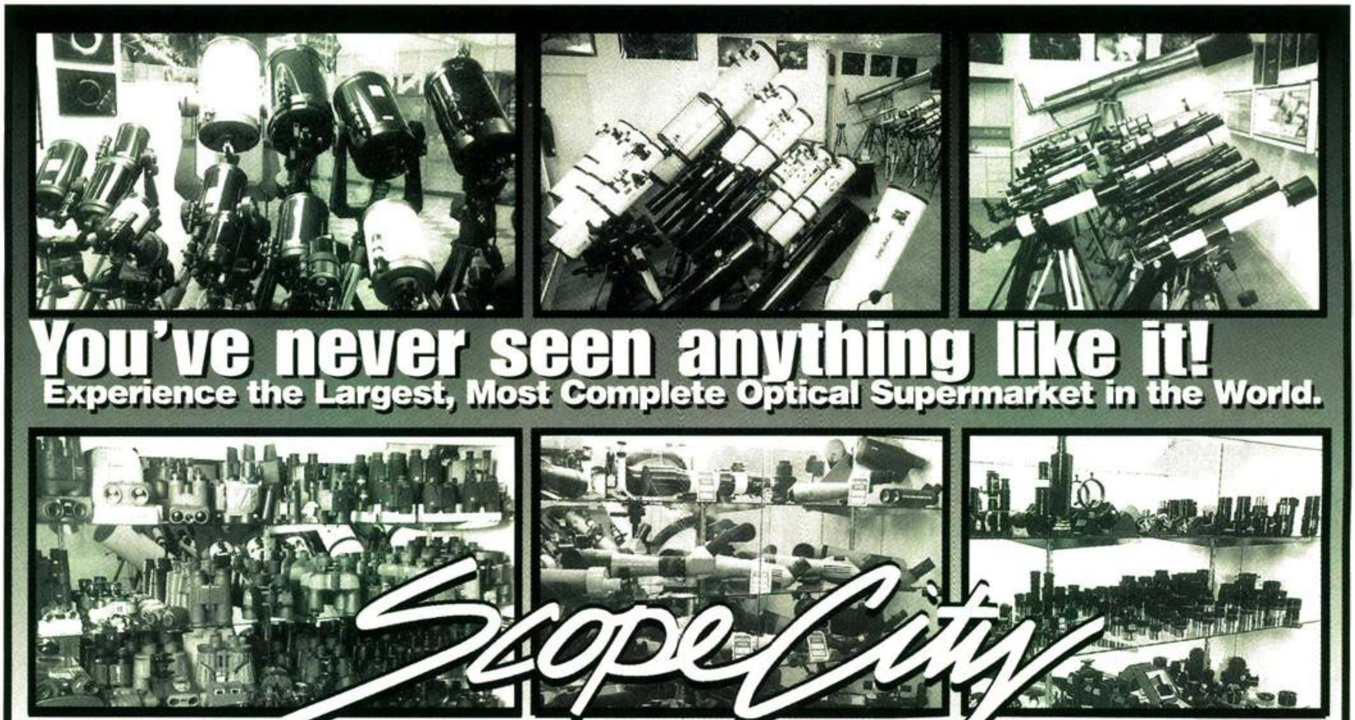

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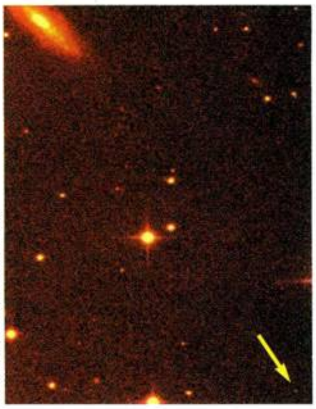

European Southern Observatory

S 2000 S 1 (arrow) glows dimly in its discovery image. The moon seems to be a collisional fragment.

singers. Continuing observations of the 12 recently discovered moons orbiting Saturn show that they are likely fragments created when their parent moons suffered massive collisions.

In days gone by, the solar system didn't seem such a crowded and violent place. For most of history, the only known moon belonged to planet Earth. Galileo quintupled that number in January 1610, when he used the newly invented telescope to discover the four bright moons of Jupiter.

As the centuries passed, many more moons were discovered, but never more than two at a time. That's all changed now. In the last few years, telescopes and technology have improved so much that moons are falling out of the sky in bunches. Five new moons were found around Uranus between 1997 and 1999, 12 were discovered orbiting Jupiter in 1999 and 2000, and a dozen more turned up around Saturn just last year.

Brett Gladman of the National Center of Scientific Research in Nice, France, and his collaborators discovered the new saturnian moons in August, September, and November 2000. Using several telescopes around the world, the team took wide-field images of the sky near Saturn once each hour. Computer software then analyzed the multi-gigabytes of data, looking for any object that moved relative to the fixed background stars.

Astronomers have now followed the new moons for nearly a year, pinning down their orbits. All appear to be small, irregular satellites, having fairly elongated orbits that stretch millions of miles from Saturn and tilt significantly to the planet's equatorial plane. Gladman and his colleagues report their findings in the July 12 issue of *Nature*.

Most interesting, the orbits appear to cluster into three or four distinct groups, with the orbits in each group sharing similar characteristics. "We think we're seeing orbits cluster just as asteroids cluster," says team member Carl Hergenrother of the University of Arizona's Lunar and Planetary Laboratory.

"With asteroids that cluster, the belief is they are pieces of what once was a big asteroid that got hit by something," he adds. "It's possible that we're seeing the same thing with the satellites."

The researchers think that each cluster started out as an intact moon that was captured as it passed through Saturn's protoplanetary gas cloud. Then, sometime after the planet formed, the moon was smashed by another object, perhaps a comet or asteroid. The newly discovered moons are simply the fragments of those collisions — and many more could be awaiting discovery. — R. T.

MAP Is on Its Way

How old is the universe? What happened in the instant after the Big Bang? How and when did the first galaxies form? These are just some of the questions astronomers hope to answer with the Microwave Anisotropy Probe (MAP), a spacecraft launched June 30 from Cape Canaveral. MAP will study the microwave background radiation — the cooling afterglow of the Big Bang — looking for the tiny temperature differences that point back to density fluctuations in the infant universe. MAP's ability to measure variations of millionths of a degree far exceeds that of any previous observations. A month after launch, MAP was scheduled to swing past the moon, boosting its orbit to the second Lagrangian point (L2). After a three-month journey, MAP will begin to chart the microwave background.

NASA

MAP lifts off on its mission to study the background radiation.

When the Sun Turns the Sky Gray

If the weather seems cloudier recently, you may not be imagining it. A new study has found that the United States becomes cloudier during periods of increased solar activity, like those of the past couple of years. Petra Udelhofen of the State University of New York at Stony Brook led the researchers, who reported their findings in the July 1 issue of *Geophysical Research Letters*. "Our results show that cloudiness varies on average by two percent between years of solar maximum and minimum," says Udelhofen. The researchers suggest that the jet stream, which guides storms and appears to move northward around solar maximum, may be the culprit.

New Plan for Cassini-Huygens

Scientists should still get the view of Saturn's moon Titan they've dreamed about. NASA and the European Space Agency have developed a plan to work around a communications problem between the Cassini orbiter and Huygens probe that threatened much of the probe's scientific mission (see "A Giant Awakens Cassini," April 2001). The new plan changes the probe's release date to January 14, 2005 — seven weeks later than originally scheduled — and positions the Cassini orbiter farther away during the descent. After Cassini arrives at Saturn in July 2004, it will complete three flybys of Titan, instead of two, before the probe release. The rest of Cassini's four-year prime mission to study the planet, its rings, and its moons, will remain unchanged.

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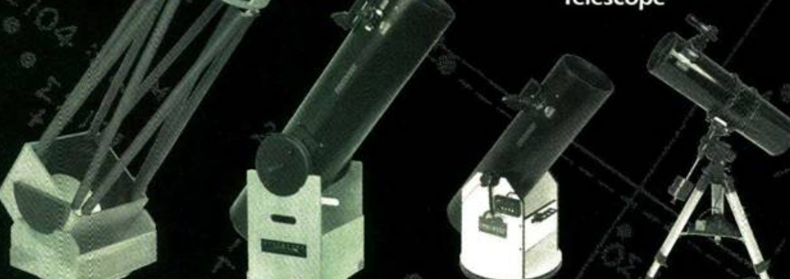

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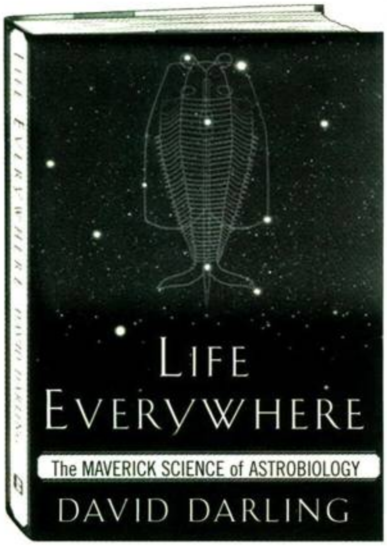

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Just wanted to let you know that the used ETX70AT scope arrived yesterday. I was very impressed with it's appearance - it didn't look used at all! Everything was there in excellent condition, as advertised (except the allen wrench, which I can pick up locally). I took it out last night under not so great skies. Everything seems to perform well (except the sky!) Thanks so much for a great buy on the ETX70AT, and for the friendly service. I will be back!

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DIVING FOR SPACECRAFT

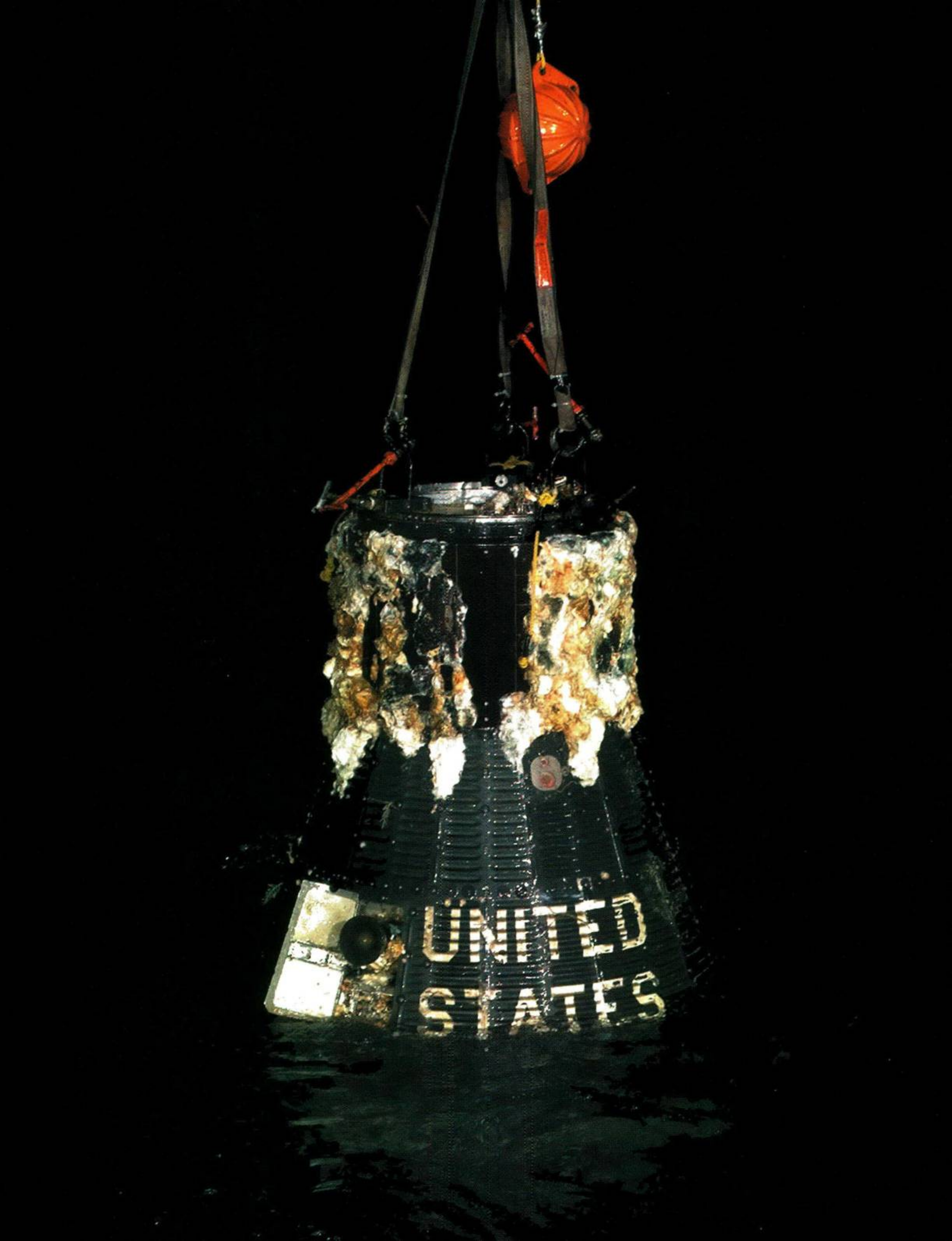
One man's quest to raise NASA's Liberty Bell 7 *brings a flood of memories to the surface.*

by Paul Perry

It's 1:07 A.M., April 29, 1999, and Curt Newport is deeply distressed. He's nearly broke and living on borrowed time. After 15 years of exhaustive research and fundraising, when everything was finally coming together, Newport is bracing himself for what seems like the imminent death of his dream — to find and recover America's lost *Liberty Bell 7* space capsule.

For five days now Newport and his salvage crew have sailed back and forth atop 16,000 feet of deep-blue ocean 300 miles off the coast of Florida, in search of the notorious Project Mercury spacecraft, which splashed down and sank nearly 40 years ago after a 15-minute suborbital jaunt with NASA astronaut Virgil I. "Gus" Grissom in the hot seat. As NASA's second attempt to hurl a man into space and bring him back alive, the voyage of the *Liberty Bell 7* — the name Grissom had chosen for his bell-shaped craft — was a far cry from being the perfect sequel to Alan Shepard's historic maiden flight two months earlier. Luckily, Grissom was rescued only seconds before his vessel filled with water, but the answers to why it sank went down to rest with the *Liberty Bell 7*.

Bringing liberty home: Barnacled with brine deposits from the bottom of the Atlantic Ocean, Grissom's Mercury space capsule (*Liberty Bell 7*) breaks the surface after nearly 40 years in the deep. The effort to find and raise the *Liberty Bell* lasted more than 15 years. Discovery Channel (DC)


UNITED
STATES

OCEANEERING

Now, after covering almost each and every inch of the 24-square-mile target area, Newport and his gang are beginning to wonder if they'll go home to a hero's welcome or return as empty-handed nobodies. And the rest, as they say, is history.

15 Minutes of Fame

On July 21, 1961, Grissom sat atop a Redstone rocket, hurtling toward space at 5,000 miles per hour. His heart rate rose to 150 beats per minute as his Mercury space capsule separated from the booster rocket. With little time for reflection, Grissom soon found himself weightless in shallow space.

After performing a few short pitch and yaw maneuvers, Grissom turned the Mercury spacecraft around, aiming the heat shield at Earth's atmosphere and firing off the tiny vessel's retrorockets for reentry. This was the most dangerous in a chain of perilous events faced by Grissom. If the rockets failed to ignite or deliver enough thrust, the spacecraft could land almost anywhere, even in the densest jungle or steepest mountain range. But that didn't happen. The rockets fired flawlessly and the *Liberty Bell 7* plowed through the stratosphere, glowing and intact. Throughout reentry, the added force caused by the craft's deceleration burdened Grissom with as much as 11 times his own bodyweight.

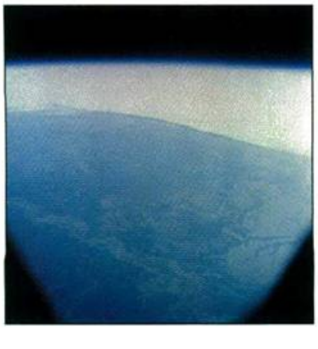
At 21,000 feet, the drogue chute popped out, steadying the bell-shaped capsule and slowing its descent. At 11,000 feet, the parachute that would assure a soft ocean landing popped open, giving Grissom a secure jolt. Soon the capsule splashed down in the waters north of the Grand Bahamas. Three miles away, two helicopters raced from the deck of the aircraft carrier USS *Randolph* to retrieve Grissom and his capsule.

So far, everything had gone off without a hitch . . .

Yet to be Found...

"*Liberty Bell 7* wasn't the last remnant of the early space program waiting to be found," says Curt Newport. The Atlantic Ocean still lays claim to a short list of booster rockets and one test spacecraft.

- The hatch from *Liberty Bell 7*.
- Seven Saturn V rocket stages from several Apollo missions.
- A Redstone rocket booster lost off Cape Canaveral.
- Mercury test capsule wreckage near Wallops Island, Virginia, which Newport searched for in the 1990s but was unable to find.



OCEAN EXPLORER 6000

Left to right: The crew hits the high seas in search of Liberty. Underwater astronaut Curt Newport casts a hopeful smile. The workhorse sonar is plucked from the water. Grissom wasn't in the water long enough to worry about sharks.

Reed Hoffmann, R. Hoffmann, DC, R. Hoffmann

"Okay, give me how much longer it will be before you get here," Grissom radioed to helicopter pilot James Lewis, a Navy lieutenant.

"This is Hunt Club 1. We are in orbit now at this time, around the capsule," said Lewis.

"Roger, give me about another five minutes here to mark these switch positions before I give you a call to come in and hook on," said Grissom.

"Hunt Club 1, roger, we are ready any time you are," said Lewis.

The helicopter hovered for five and a half minutes.

"Okay Hunt Club, this is Liberty Bell," said Grissom. "Are you ready for the pickup?"

"This is Hunt Club 1, this is affirmative," Lewis answered.

The helicopter swung low over the capsule while Lt. John Reinhard, the co-pilot, prepared the helicopter's hook to snag a loop at the top of the capsule and pull it from the water. Just as the helicopter got into position, Lewis saw the spacecraft's escape hatch blow off its hinges and skip across the water. Right behind it was Grissom, escaping into the relative safety of the sea as water rushed into the sinking capsule.

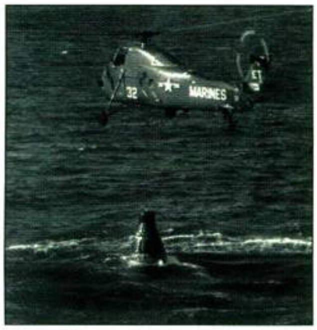
The Navy crew quickly hooked the capsule, but the waterlogged *Liberty Bell 7* now weighed 5,000 pounds, one thousand pounds more than the helicopter was designed to lift. Red dash lights blinked, warning of engine failure, and slowly the helicopter was dragged down until its wheels were literally submerged in the water.

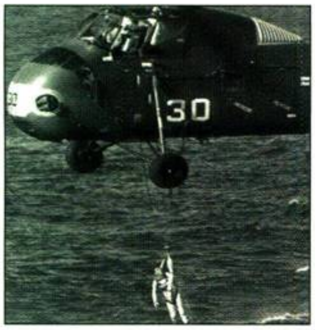
Lewis had no choice but to cut the capsule loose and let *Liberty Bell 7* drop into the deep.

Making His Mark

Since 1984 Newport had wanted to make a name for himself in the undersea world. By that time, he had already spent eight years as an astronaut of inner space, flying Remotely Operated Vehicles (ROVs) into the ocean depths. At the bottom of the sea, he is literally able to go where no man has ever gone, and recover what has been lost, sometimes tragically.

In 1986 Newport was involved with the recovery of the space shuttle Challenger, which exploded less than a minute into its flight. The unforgettable blast rained wreckage over a 400-square-mile area of the Atlantic Ocean. Despite a salvage effort that involved dozens of ships and thousands of personnel, Newport says that a large portion of the shuttle is still lost, deep in the ocean. "There was no way to get it all," he says. "Pieces of the shuttle still wash up on shore."



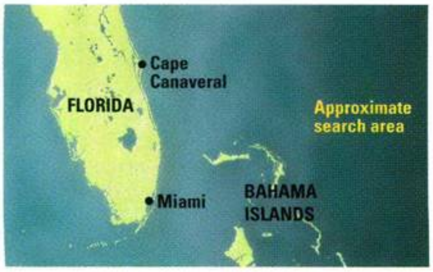


Newport, who has also searched for rare pink coral in Taiwan and worked on offshore oil rigs, has been part of salvage operations following many tragedies, including TWA Flight 800, Air India Flight 182, and a number of military aircraft crashes.

"I was making a good living," recalls Newport. "But I wanted to do something interesting with the technology. I wanted to rewrite history."

Newport's first idea was to find the *Titanic*. Many people had discussed searching for the lost luxury liner. Indeed, adventure writer Clive Cussler had penned *Raise the Titanic*, in which the ship is pumped full of air and brought to the surface. Possible, perhaps. But the problem was that no one knew exactly where the *Titanic* was.

Newport went to work on that question. He examined navigational charts and figured out how far the crippled ship had drifted after striking the iceberg in 1912."I was hot on her tail," says Newport. "Then Ballard came in and scooped me."



Unknown to Newport, Robert Ballard had the same goal. The Woods Hole Oceanographic Institute researcher commanded a high-tech expedition aboard the research vessel *Knorr* and found the massive ship on August 31, 1985.

Newport was disappointed that someone else had found his choice target. But there was gratification even in defeat. "Plotting the location with charts, I had predicted where the *Titanic* was to within three miles," he says, a feat in and of itself.

As news about Ballard's stunning find hit the press, Newport switched his focus to Plan B: *Liberty Bell 7*.

Bringing Back Memories

A target smaller than one of the *Titanic's* lifeboats, *Liberty Bell 7* had a big history. For baby boomers, the sinking of Grissom's spacecraft ranked high in their memories along with events like the Kennedy assassination and the Vietnam War.

"Finding *Liberty Bell 7* had a lot of public sex appeal," offers Newport. But the most appealing aspect of the project to him was the fact that no one had looked for the capsule. The reason: "It was in such deep water that NASA wasn't even thinking of looking for it."

In June 1985, Newport started researching Gus Grissom and *Liberty Bell 7* while in Ireland as part of the recovery team for the Air India 747 crash. In between piloting his ROV through wreckage, Newport spent hours in the libraries of Cork, pulling together all the research he could on the short and fateful spaceflight.

"I came back to the United States with a head full of research and $34,000 to live on," recalls Newport.

He continued his research at the NASA archives in Washington, D.C., and almost convinced administrators at the space museum at Cape Canaveral to fund a search expedition. But they pulled out at the last minute, citing expenses and uncertainty over whether the craft could be found.

Later, after finishing his work at the shuttle recovery site, Newport returned to the Kennedy Space Flight Center in Florida to put the finishing touches on his *Liberty Bell 7* research. Through the Freedom of Information Act, Newport gained access to reams of flight data from Florida, as well as Rice University in Houston, Texas, and the Marshall Space Flight Center in Huntsville, Alabama. All of this would ultimately help him pinpoint the location of *Liberty Bell 7*.

Through a space memorabilia dealer, Newport was introduced to Lt. Gen. Tom Stafford, an Apollo and Gemini astronaut. Not only did Stafford give Newport a set of blueprints for the tiny Mercury spacecraft, but he introduced him to a number of the engineers who had tracked *Liberty*

Left to right: The original "Mercury 7" pose in front of a Mercury capsule (Grissom at center). A 1964 shot of NASA's Missile Row symbolizes America's commitment to win the race for space. All systems go, Grissom poses for one last photo op. All photos: NASA

Bell 7 via radar on its fateful flight. Through their interpretation of the data, he was able to narrow the search field to three by eight miles.

Although the potential search field had narrowed, the search for funding had not. To this day, Newport proudly waves a file folder filled with rejection letters from some of the most powerful people and organizations in the country, including Ross Perot, Tom Hanks, and the National Geographic Society.

Newport can afford to be proud because, although he was in a tight spot, much like Grissom after his fateful spaceflight, Newport eventually managed to convince Discovery Channel executive Mike Quattrone that he had a reasonable chance to make good on his promise to find the lost space capsule. In 1998, the Discovery Channel finally agreed to finance Newport's expedition and shoot a documentary of the unfolding events.

Coming to a Town Near You

Through 2003 (with a possible extension to 2005), *Liberty Bell 7* will be touring the United States. Here is the most current schedule:

June 29 – Sept. 15, 2002
Chabot Observatory and Science Center, Oakland, California.

Oct. 5, 2002 – Jan. 26, 2003
Denver Museum of Nature & Science, Denver, Colorado.

Feb. 15 – May 26, 2003
Smithsonian National Air and Space Museum, Washington, D.C.

June 14 – Sept. 7, 2003
Ft. Worth Museum of Science & History, Fort Worth, Texas.

Sept. 26, 2003 – Jan 4, 2004
Science City, Kansas City, Missouri.

Summer of '61

That summer day in 1961, only the arrival of another helicopter and the lowering of a horse-collar to pull Grissom up prevented him from going down with the *Liberty Bell 7*. Grissom was so exhausted and fearful from the near drowning that he strapped on a Mae West life jacket as soon as he was brought on board.

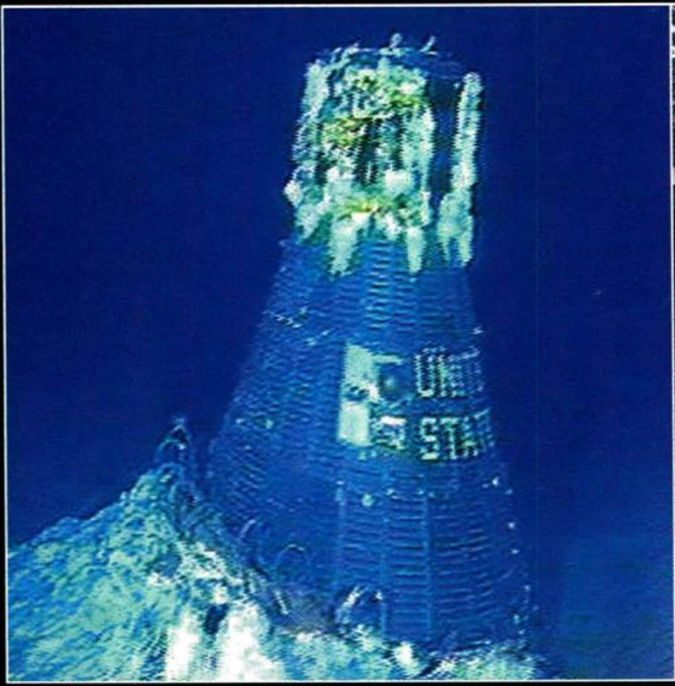
At the mission debriefing, Grissom denied that he had "screwed the pooch" — a term used by astronauts to designate a pilot error. "I didn't touch [the hatch]," said Grissom during one of these exhaustive interrogations. "I was just lying there — and it blew."

Impossible, said some of the technicians. Grissom must have accidentally hit the actuator, blowing off the hatch and filling the craft with water. There was no other way it could have happened, they insisted. They had tested the detonator in every possible way, including dropping one of the things onto concrete from 100 feet high. None had ever gone off accidentally.

NASA conducted extensive testing to see what — besides human error — could have caused the hatch to blow. They considered a variety of scenarios, including "omission of an o-ring seal on the detonator plunger," chemical action of seawater on the explosive, and static electricity discharge between the helicopter and spacecraft.

Their conclusion? "No satisfactory explanation for the apparent spontaneous actuation of the hatch has been found to date," reads a confidential NASA report. Thoughts that Grissom must have accidentally punched the activation plunger with his elbow persisted amongst NASA engineers, but ultimately everyone concerned just let the issue drop. After all, we were deadlocked in the race for space against the Soviet Union.

And besides, the evidence was untouchable, sitting on the bottom three and a half miles underwater. Exact location: unknown.



Going for Broke

Four days and counting, Newport thinks. He's just been told by a Discovery Channel producer that he only has four days worth of funding left to find *Liberty Bell 7*. She called him via a crackling satellite phone to break the news. Her words have left him feeling sick to his stomach. With or without the space capsule, Newport must return to port at midnight on Tuesday.

So far Newport's team has charted 70 targets — they will chart 88 before the search is through. As Newport does the math in his head to figure out how many more hours he can afford to search for the tiny spacecraft, a pulse of electricity zips down a coaxial cable five miles long, where it passes through a sonar and out into deep ocean. As Newport mulls over the expedition's finances, the impulse returns to the sonar and back up the cable, showing up as a blip on the sonar screen.

"Hard target across ravine," barks the sonar operator.

The newly discovered target is identified as target 71 and dutifully recorded on a contact sheet.

Failure Never Looks Good

Taking a deep drag off a cigarette, Newport can feel the weight of the world on his shoulders. After 15 years of research and planning, he is finally using his technical skills to make his mark in undersea exploration. Only four months earlier, the Discovery Channel had agreed to fund a search for *Liberty Bell 7*. Now, with 71 targets discovered, Newport knows that he'll only be able to examine a handful of them with his ROV before the money runs out.

I wish we hadn't held that press conference before we left port, Newport thinks. *Failure won't look good in the newspapers.*

Newport looks out at sea and feels exactly what he is — a man in deep water with no shore in sight. He crushes out his cigarette and returns to the sonar room.

Bleary-eyed technicians sit gazing like hypnotized zombies at the screen; Newport hunkers down to join them.

Pressing On

Later that day, Newport and his team will find and chart 17 more targets. With 88 total targets on the charts, Newport orders that the sonar be brought up and the ROV be prepared to go down. He and four other technicians have whittled the targets down to the 16 "greatest hits" — promising objects that possess the sonar characteristics of the metal spacecraft they are looking for.

Once again, Newport does the math. With 16 targets grouped into three areas, they will be required to launch and recover the *Magellan* ROV three times, for a total of 24 hours. If they manage to locate and visually identify each of the 16 targets in six hours, that alone will take four days. And that doesn't count the transit time from one target to the next. Finding *Liberty Bell 7* would require extraordinary luck.

Newport takes a long look at the charts for the most likely targets. It's time to roll the dice. "You see the six targets in this area?" Newport asks one of the technicians.

"Yeah."

"Let's start with this one, number 71, work our way south towards target 54, then turn east, picking up number 28 until we get to target 61. If we haven't found it by then, we'll head back to north via 14 and finish up this area with target 13."

"OK. But what if we don't find it on this dive?"

"Let's worry about that later."

Voyage to the Bottom

On May 1st, 1999, the search ship *Needham Tide* hovers over target 71 and the big deck crane lowers *Magellan* into the water. Two and a half hours later it slips past the 9,000 foot mark. At three hours it reaches 14,000 feet, well past the depth of the *Titanic*. Four hours later the surrounding water temperature plunges to a frigid 36°, where ambient light is nonexistent, and the water pressure boasts a crushing 7,127 pounds of force per square inch.

Magellan reaches the bottom: 16,040 feet.

One of the pilots begins flying the ROV, searching the bottom for the first target — number 71. The ocean bottom illuminated by the ROV's headlights appears eerie. Waves of sand, formed by ocean currents, become the playground of the pilot as he crashes the ROV through the crests. Newport isn't pleased.

"I'll take over," he says.

Newport flies *Magellan* over the top of a sand wave and then down the other side. In the distance, just out of the searchlight's reach, a large object looms. As Newport turns *Magellan* to make for the object, the shape of a bell begins to emerge in the light. Suddenly, in the full glare of the headlights, appear the words UNITED STATES.

Mayhem fills the control shack as Newport covers his face and everyone starts to roar. Success!

On the search of the first target, *Liberty Bell 7* is found.

Bringing Liberty Home

Left to right: Flood lights of the *Magellan* ROV rouse *Liberty Bell 7* after 38 years in the deep. Newport inspects the raised capsule on deck. Project Mercury spaceflights were a crucial step in securing the moon, one of humankind's greatest achievements. DC, DC, NASA, NASA

Liberty Bell 7 is now in the possession of the Kansas Cosmosphere and Space Center in Hutchison, Kansas. Conservators have restored much of the craft to its previous glory, especially the titanium skin, which was largely unaffected by 38 years of saltwater immersion. Much of the capsule — wires and the paneling in front of it — had corroded away. The same was true of a film made of the entire space flight. The camera mounted inside the capsule was recovered, but the film inside had been destroyed in the deep ocean environment. Had that film survived, we might have known whether Grissom really "screwed the pooch" on that fateful day in 1961.

Examining the hatch itself also could have provided answers. But when it blew in 1961, the hatch drifted to the deep alone, swirling like a leaf from a tree. It still rests on the bottom.

"I figure it's about a mile away from the *Liberty Bell* site," says Newport. "I had what I thought was a target for it, but I didn't have time to look for it. No one wanted to foot the bill."

Tragic Irony

NASA escape hatches were eventually redesigned because of Grissom's Mercury fiasco. The resulting Apollo hatches were much more secure, but also much harder to open quickly. Ironically, it was quick egress that was necessary on January 27, 1967.

An oxygen fire suddenly ignited while Grissom (left) and his Apollo crewmates, Edward White and Roger Chaffee (center and right, respectively), were training inside the Apollo 1 spacecraft as it sat on the pad at Cape Kennedy. Within seconds the capsule became engulfed in flames.

Despite efforts both inside and outside the spacecraft, Grissom, White, and Chaffee perished on the launch pad. It's generally agreed that a quick-releasing hatch like the one on *Liberty Bell 7* would have saved the lives of the Apollo 1 crew.

Paul Perry has written three New York Times *bestsellers and is currently authoring a book on pirate captain William Kidd. This is his first article for* Astronomy.

HEART OF DARKNESS

A massive black hole at the center of our galaxy dominates everything in its neighborhood.

by Robert Zimmerman

In the early 1930s, a researcher working for AT&T's Bell Laboratories in New Jersey invented a new science. Karl Jansky had built an antenna to search for radio sources that might interfere with trans-Atlantic telephone communications. He recorded three types of static: a steady, weak hiss emanating from Earth's ionosphere, a "crash type" static caused by nearby thunderstorms, and a mysterious continuous radio signal coming from the region of the constellation Sagittarius.

Radio astronomy had just been born. Although the antenna's resolution (24 by 35 degrees) was far too coarse to pin down what he was observing, Jansky was convinced he had discovered a specific and previously unknown interstellar object. That its approximate location placed it near the center of the galaxy was enough for the newspapers of the day, among them *The New York Times*, to label it so.

Now, nearly 70 years later, our knowledge of the Milky Way's core is exploding like the number of phone companies created since the breakup of Jansky's employer. Yet nothing found to date can compete with the discovery of a massive black hole that lurks right at the galaxy's center. Unseen yet crushingly powerful, this black hole and its enigmatic surroundings remain one of astronomy's most tantalizing mysteries.

The central half-degree of the galaxy comes alive with countless stars, clusters, and intervening clouds of dust when viewed in the near-infrared. Ian Gatley

Despite containing a mass 2.6 million times that of the sun, the central black hole doesn't take up a lot of space — its diameter of about 10 million miles is only 11 times the sun's. Yet even from a distance of around 27,000 light-years, the core screams its presence, emitting radio waves that any radio telescope can detect. The black hole's titanic gravitational field dominates the Milky Way's core. Some astronomers believe that recently — maybe only a few thousand years ago — a supergiant star came too close and was ripped apart in a fiery explosion hundreds of times more powerful than the biggest supernova.

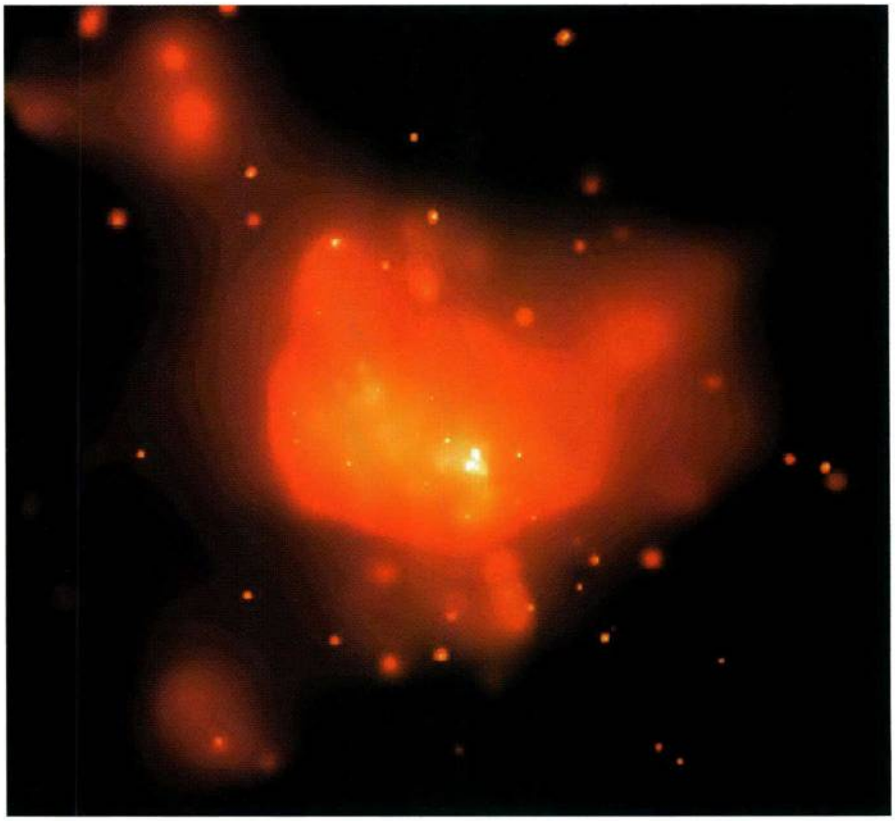
The core's immense gravity has shepherded to it a gigantic vortex of gas and stars. Like silken drapes blown in the wind, the erupting waves of gas from scores of supernovae sweep through an inner region approximately 350 light-years across, filling space like froth and geysers. Here supergiant stars — many times more massive than the sun and rare elsewhere in the galaxy — number in the hundreds. And within those 350 light-years are three of the galaxy's densest and most massive star clusters, surrounded by millions of additional stars. So packed is this core that if the solar system were located there, a handful of stars would float amid the planets.

The core's brutal environment apparently makes a productive breeding ground for new star birth — something most scientists had not expected. Despite intense gravitational fields, tidal distortions, and strong magnetic fields, dense clouds of gas and dust have repeatedly coalesced into regions of furious star formation, and in many cases very near the central black hole. "We don't yet understand what's happening in terms of star formation at the center of our galaxy," says Don Figer of the Space Telescope Science Institute. After a 70-year hunt, the core of the Milky Way is being slowly unveiled, but that revelation is simultaneously exposing innumerable new questions.

Finding the Center

The modern quest for the core of the galaxy began with Jansky in 1932, just three years after Edwin Hubble proved that the Milky Way was one of billions of "island universes," or galaxies. In the 1950s, with the advent of better radio telescopes, astronomers in Australia were able to pinpoint the source. They gave it the name Sagittarius A, denoting it as the brightest radio source in the constellation. This discovery did not explain much, however. No counterpart at any other wavelength was identified, and the resolution of those 1950s radio images was still very coarse.

Hubble's NICMOS camera captured the massive young Quintuplet Cluster located at the heart of the Milky Way. Don Figer (STScI) and NASA



Sagittarius East, a huge bubble that might be a supernova remnant, engulfs A* (at center) in this Chandra image. NASA/Penn State/ G. Garmire, et al.

Optical telescopes saw nothing at all, their vision forever blocked by the thick dust clouds in the spiral arms of the galaxy that obscure as much as 30 magnitudes of light from reaching our solar system. If that much dust floated between the sun and Earth, the sun would never shine brighter than a 4th-magnitude star, equivalent to the dimmer stars that make up the handle of the Little Dipper.

Despite the observational limitations, most scientists in the 1950s and 1960s believed that Sagittarius A was either at the Milky Way's core, or at least very close to it. Its nature, however, remained a complete mystery.

By the mid-1970s, radio astronomy, supplemented by images made in the infrared, had advanced sufficiently to resolve several sources in the hazy radio images. The three most prominent fuzzy shapes in the core were named Sagittarius East, Sagittarius West, and Sagittarius A* (pronounced A-Star). While East and West were large cloud-like formations that partly overlapped, A* was near their center and appeared as a pointlike radio source, still lacking a counterpart at any other wavelength.

Discovered by Bruce Balick and Robert Brown in 1974 during a search for exotic and strange objects, Sagittarius A* received its unusual name from Brown, who wanted to delineate its uniqueness. Their data showed A* to be small — they estimated it to be less than 2 billion miles across, about half the size of the solar system. Yet, "what we were looking at could not be a star," remembers Brown. A* shone with a temperature between 100,000 and 1 million kelvins, far hotter than any other object known in the galaxy.

In the 1980s and 1990s, astronomers using both improved infrared telescopes and the Very Large Array radio telescope in New Mexico were able to image the swirls of dust and gas spiraling around Sagittarius A*. For the first time it was possible to "see" the objects surrounding the Milky Way's center.

The core's outer regions, stretching 50 to 350 light-years from the center, were bursting with activity. Most prominent in these early images were light-year-long strands of gaseous filaments and arches — lined up parallel to one another and oriented at right angles to the galaxy's equator. Their shape and orientation implied an interaction with the core's magnetic field, which some astronomers believe is made of two components: vertical magnetic field lines emanating from the core's poles, surrounded by a spiral of field lines rotating around the core's equator. This field, while only five-thousandths the strength of Earth's magnetic field, packs enormous power because it spans many light-years.

Repeated observations of the core have since added numerous details. The longest filament, named the Radio Arc and located less than 100 light-years from Sagittarius A*, has two monumental star clusters embedded nearby. Dubbed the Arches and Quintuplet clusters, each contains more massive supergiant stars than found in all the rest of the galaxy. In the Arches alone, astronomers think there are at least ten stars 120 times more massive than the sun.

In the Quintuplet Cluster — named because five very bright objects stand out most in infrared photographs — sits the Pistol Star. Thought to be the brightest star known in the Milky Way, it routinely shines with the light of at least 4 million suns. Likely born as a star weighing between 150 and 300 times what the sun does, the Pistol Star has such a strong stellar wind that it loses 10 to 20 suns' worth of material every million years. Four to six thousand years ago, the star had a particularly powerful eruption that ejected about 10 solar masses in one burst and produced the Pistol Nebula (named for its shape), within which the star now resides.

Astronomers estimate the age of the Arches Cluster to be no more than 2 million years, while the Quintuplet cluster is about 4 million years old. These young ages suggest that the Milky Way's core has undergone at least two bursts of star birth in recent times. Other evidence implies that this inner region might contain another 10 to 40 similar clusters — hidden behind the swirls of dust and gas or lost among the innumerable background stars — and suggests the possibility of many more recent starbursts.

Even more dramatic evidence of the furious pace of recent star formation at the galaxy's core is the number of supernova remnants that the radio and infrared images reveal. In a region less than 350 light-years across, astronomers can now identify about a half dozen supernova remnants. Furthermore, astronomers estimate that from 100 to 1,000 supernovae have probably occurred in this tiny volume over the past few million years.

Making this stew even more turbulent is what scientists believe is a mysterious source of emissions caused when electrons collide with their antimatter counterparts, positrons, and annihilate one another. Since the 1970s, astronomers have detected this positron annihilation emission coming from the galactic center. In 1997, a team led by William Purcell of Northwestern University used the Compton Gamma Ray Observatory to find that this source appears as a gigantic fountain of positrons thousands of light-years long that flows out of the galactic center at right angles to its plane.

Dieter Hartmann of Clemson University and others have theorized that the many supernovae in the core over the past few million years might have caused this fountain of antimatter. Astronomers have also proposed that a single gamma-ray burst at the galaxy's center about a million years ago might have produced the antimatter stream. Still other scientists are unsure the fountain even exists — "It hasn't yet been confirmed," notes Fulvio Melia of the University of Arizona.

Streaming Clouds

Observations in the last two decades have looked deeper into the core's inner 30 light-years and revealed an even more complex spray of gaseous structures. Sagittarius East is now believed to be a large bubble, possibly one of the largest supernova remnants known, that formed fewer than 100,000 years ago and maybe as recently as 10,000 years ago. Although it engulfs Sagittarius West and Sagittarius A*, it lies mostly behind both. Astronomers think that the energy required to punch out this shell of gas in such a dense region would have to be as much as 50 times greater than the most powerful supernova explosion.

What could have produced this much energy still puzzles astronomers. Some theorize that Sagittarius East was created when a star approached within 50 million miles of the central black hole and was torn apart by the strong gravity. Others suggest that perhaps it was caused by the supernovae that erupt so frequently in this region. Still others propose that a gamma-ray burst

This 2° by 5° infrared mosaic shows the bright galactic core (yellow) immersed in stars and dust. 2MASS/Univ. of Massachusetts/Caltech/IPAC/NSF/NASA (whose origin itself remains speculative) might have generated it.

Sagittarius West, meanwhile, has been resolved into a smaller spiral of clouds 10 to 20 light-years across. The Mini-spiral, as astronomers have dubbed it, seems to encircle a region including the point radio source Sagittarius A* as well as an infrared source, named IRS 16, a cluster of massive, short-lived stars, either Wolf-Rayets or Luminous Blue Variables.

Repeated observations since the early 1980s have attempted to unravel the complexity of this inner vortex. Unfortunately, astronomers can take only two-dimensional images of this three-dimensional object, so understanding has not come easily.

The Mini-spiral appears to consist of three main components — a Western Arc, a Northern Arm, and a Central Bar. The Western Arc, located only about two light-years from the center, appears to define the inner edge of a gigantic clumpy ring of molecular gas called the Circumnuclear Ring, which spins around the core at a slight tilt to the plane of the galaxy. Rotating at about 70 miles per second, this clumpy ring extends outward from about two to seven light-years from the core. It's made up of dense and relatively hot gas (about 70 kelvins), heated by the intense winds from the stars in IRS 16.

The two-light-year-wide bubble inside the Circumnuclear Ring appears relatively less dense, except for the stream of gas that makes up the Northern Arm and the Central Bar. "You have a cavity that is not quite a cavity," says Fadeh Yusef-Zadeh of Northwestern University. Yusef-Zadeh led a team that studied the gas stream and found that it flows past Sagittarius A* at an enormous speed, almost 400 miles per second, rushing down the Northern Arm and whipping out along the Central Bar. Although the origin of this stream is still unclear, some astronomers theorize that its shape and existence is the consequence of another star's breakup several million years ago. Others say that the flow originated from one of the clumpy gas clouds orbiting Sagittarius A* in the Circumnuclear Ring. During a recent orbit the cloud could have approached the black hole too closely and been funneled into this narrow stream by the intense gravity.

This inner region is also whipped by other stellar winds, coming from the bright stars of the IRS 16 complex as well as other nearby supergiant stars. The winds blow material all over, tearing at the fabric of these clouds. One example lies to the southwest of Sagittarius A*, in a bubble region called the Mini-cavity. The intense stellar winds coming from the Wolf-Rayet stars in IRS 16 apparently drove past Sagittarius A* and blew out the bubble.

Spinning Stars

By the 1980s, astronomers suspected that Sagittarius A* might be a supermassive black hole at the center of the galaxy. Yet they still had no direct evidence to prove this supposition.

Fortunately, the technology used in infrared telescopes had finally become sophisticated enough to allow astronomers to photograph the brightest individual stars near the galactic center. By taking infrared photos over a period of several years, the motions of the stars located within a light-year of Sagittarius A* could be charted. Here astronomers found a third giant star cluster, called the Central Cluster, a region so packed with stars that within the inner three light-years almost a thousand stars have been identified. Imagine a thousand stars — most of which are 10 to 100 times bigger than the sun — stuffed into the same space occupied by the sun and its nearest neighbor, Alpha Centauri.

In 1997, astronomers Andrea Eckart and Reinhard Genzel of the Max-Planck-Institut in Germany announced that they had mapped the motion of about 70 stars nearest to Sagittarius A*. They found that many of the stars were streaking across the sky at tremendous speeds, and that the closer to Sagittarius A* the stars were, the faster they moved. Stars at distances of more than half a light-year traveled at less than 100 miles per second. Closer in, the speeds increased to more than 500 miles per second, and the closest star to Sagittarius A*, dubbed S1, also had the fastest velocity, estimated at almost 900 miles per second.

Furthermore, Eckart and Genzel found that the 100 nearest stars seemed to be moving in a generally clockwise direction, opposite to the rotation of the rest of the galaxy. This suggests that they were part of a large torus of stars orbiting a single invisible point.

At the center of this whirling collection of stars was the radio source Sagittarius A*, which unlike any other star in the sky has no apparent proper motion. Mark Reid of the Harvard-Smithsonian Center for Astrophysics observed Sagittarius A* with the Very Long Baseline Array, a system of 10 radio telescopes that stretches from the Virgin Islands to Hawaii and can pinpoint the location of an object more precisely than any other technique. After two years of tracking Sagittarius A*, he found the only evidence of motion was attributable to our own sun's orbit around the galaxy.

2MASS imaged the galactic plane, capturing more than a million stars and the core (in red, below center). 2MASS/Univ. of Massachusetts/Caltech/IPAC

Inner Mysteries

For most astronomers, the only apparent explanation for a single, motionless object sitting right at the center of a whirligig was that Sagittarius A* was a supermassive black hole weighing 2.6 million times the sun, around which the stars — and even the galaxy — revolved.

Yet, if Sagittarius A* is a supermassive black hole, astronomers remain somewhat puzzled as to why it seems to accrete so little matter. The intense gravity of a black hole should pull in plenty of material, and certainly the galaxy's core contains a lot of that. According to most theories, as matter falls into the black hole it should produce intense energy emissions. Sagittarius A* does emit radio waves and x rays (though at nowhere near the rate of the supermassive black holes located at the center of other galaxies); however, it does not emit at any other wavelength in any appreciable amount, as far as any scientist has found.

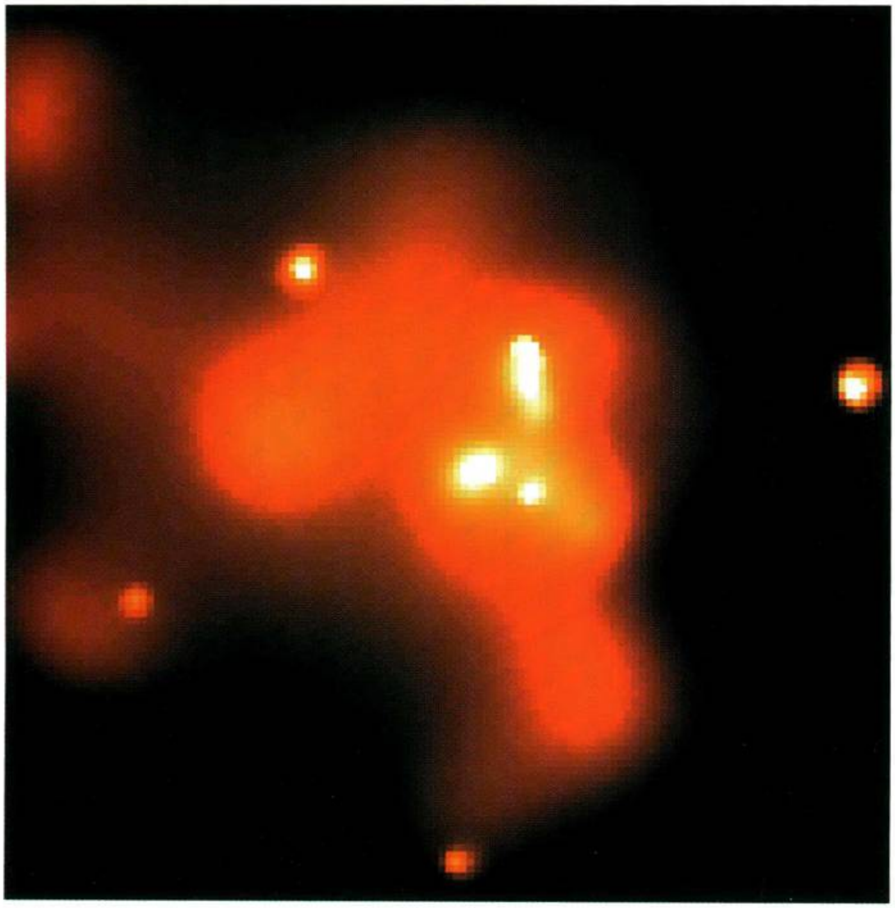
Or as Heino Falcke of the Max-Planck-Institut has written, "Sagittarius A* is currently . . . on a starvation diet," despite its location within a complex region of dense clouds and massive stars. It's as if the black hole floats in the middle of an ocean and simply refuses to get wet.

To explain this strange set of affairs, astronomers have tried several tacks. Some have attempted to explain Sagittarius A* as something other than a supermassive black hole. One alternative theory proposes that a cluster of 25,000 stellar mass black holes — much like an invisible globular cluster — lurks at the galaxy's core. The problem with this theory is that astronomers can't envision how such a cluster could exist for very long; the intense gravity fields in the central regions would disrupt it in just a few million years. So for Sagittarius A* to be a cluster of black holes, it must have formed very recently, a circumstance most astronomers don't find plausible.

Theories that accept the premise that Sagittarius A* is a supermassive black hole have focused on rethinking what emissions should be expected as matter accretes. The most popular theory postulates that the very nature of a black hole swallows most of the anticipated energy release from accretion, so we don't see any. Another theory includes the presence of high-speed astrophysical jets, which could focus the release of large amounts of energy in directions away from us, while also explaining the amount of radio and x rays that are measured.

The most accurate measurements of the intrinsic size of Sagittarius A* indicate an elongated object — just what you'd expect if a jet existed. Research by scientists from both Japan and the United States suggests that the core extends 400 million miles in length but less than 100 million miles in width.

A large cloud of hot gas surrounds Sagittarius A* (the large white dot at very center) in this x-ray image from Chandra. NASA/MIT/PSU



Perhaps an even greater puzzle than the nature of Sagittarius A* is the nature of the myriad stars that lie closest to it. Recent evidence collected by Figer indicates that these stars, the very objects mapped by Eckart and Genzel, are probably very young, very hot, and very massive. Such main sequence stars, which belong to spectral types O and B, can't be older than five million years.

Scientists had always assumed that the complexity and violence of the inner regions would have made it impossible for molecular clouds to last long enough to form such stars. Instead, they had thought that the stars close to the core would be old and long-lived. Yet, here at the core, in an area only 20 times larger than the solar system and one of the harshest locales in the entire Milky Way Galaxy, Figer and others have found stars that formed only a few million years ago.

The current situation leaves most astronomers puzzled. "It is bad enough that we have young stars around the central parsec," says Figer. "It is even more unexplainable that we have young stars in close vicinity to the black hole."

One theory, which few scientists advocate with much enthusiasm, posits that the stars might have formed farther out and are now found so near the core because they orbit on highly eccentric, cometlike paths that have plunged them inward. At present there just isn't enough data to substantiate this theory — or any other for that matter. "These stars are in a very special environment," notes Yusef-Zadeh, "and may evolve differently than stars outside the central region."

The dark and violent heart of the Milky Way remains a strange and mysterious place, one that only cutting-edge observations and, perhaps, new thinking will fathom. As astronomer John Kormendy of the University of Texas notes, "The story is not yet finished." ▣

Robert Zimmerman, a regular contributor to Astronomy, *is also a contributing editor for Astronomy.com. His most recent books are* Genesis: the Story of Apollo 8 *and* The Chronological Encyclopedia of Discoveries in Space.

Going to Africa to watch an eclipse

Eclipse Chasers on Safari

by Bonnie Gordon and Richard Talcott

During her first 10 days in Zimbabwe, Bonnie Sanford had seen the rare black rhino, a pride of lions stalking impala, hippos, zebras, and hundreds of elephants. She had been in the Land Rover that was charged by a baby male elephant trying to protect his mother. She had taken all the game drives that were offered and then signed on for extras. By June 21, Bonnie was tired of waking up at 5 A.M. and sitting in airports waiting for delayed planes. She had come with her 83-year-old stepfather, Orville Bushey, who was eager to watch the eclipse, but Bonnie's enthusiasm for it was not high.

In 2001, eclipse totality ended with a splashy, long-lived diamond ring. Dave Buchla promises unexpected adventure

She went on out to the bus at 5:45 A.M. as instructed and got on for a three-hour ride from Harare to Rushinga, a village of 5,000 Zimbabweans, many of whom had never seen foreigners before. We were going to the centerline of this three-minute eclipse, first of the new millennium.

As soon as the light from the sun began to wane, Bonnie began to cry. The tears kept coming even after totality burned up in the glare of a long-lasting diamond ring. "I didn't really want to come," she said. "I thought the eclipse would be boring."

Others of the 100 *Astronomy* magazine travelers at the site had seen many eclipses. Some were awed by the special traits of this one: three brilliant prominences and the hardy diamond finish as the sun poked out between steep mountains at the edge of the moon. In the dark, Jupiter became visible first, followed by Sirius and Canopus. Twilight shown all around the edges of the sky.

Many villagers watched with us. Some were terrified to look at the sun. The government had dropped brochures from helicopters all over the region warning people not to watch the eclipse without solar viewers. The brochures neglected to mention that when an eclipse becomes total, one may safely look at the sun's corona. We brought 500 viewers with us and Zimbabwean schools provided more so that many had viewers and could share them. We turned our buses into screens so we could project an image of the eclipse.

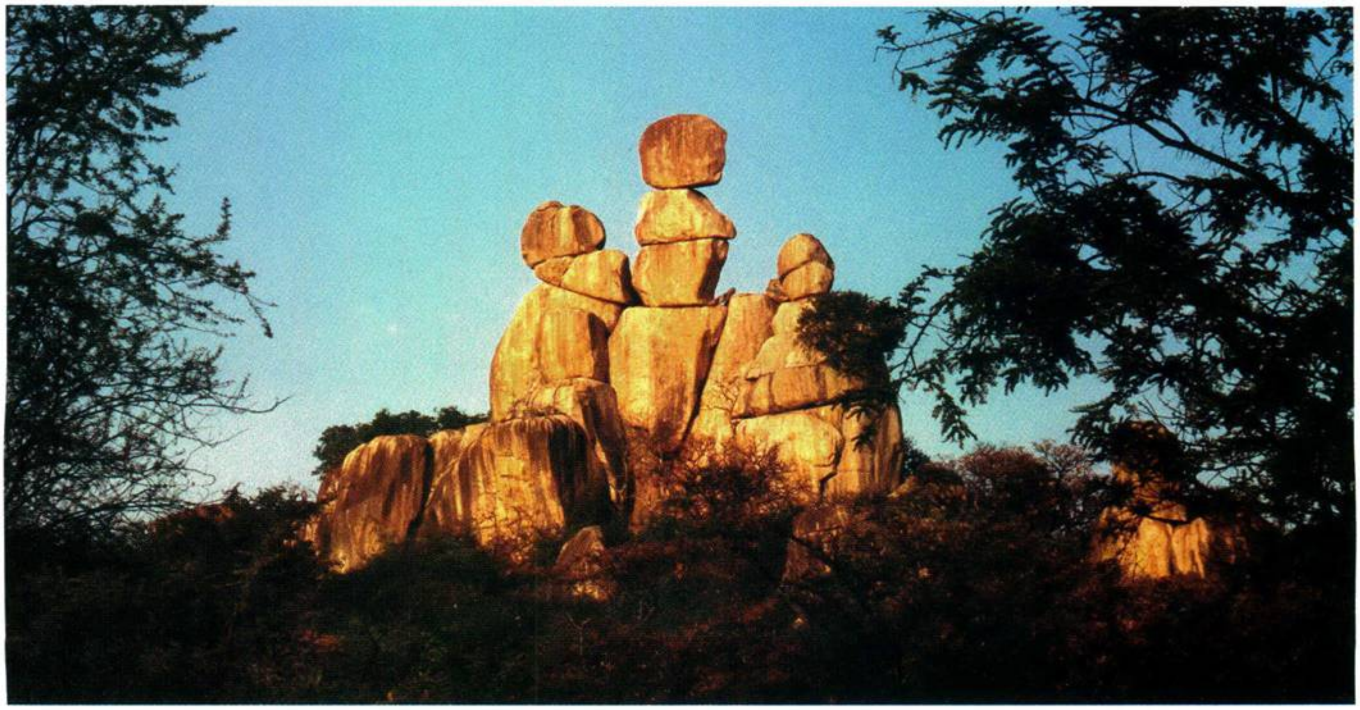
Simon Walsh, president of the Astronomical Society of Southern Africa, gave lessons in eclipse science to everyone he could reach, travelers and villagers both. *Astronomy* senior editor Rich Talcott was moving from one cluster of people to another explaining what they should watch for as the eclipse deepened: sharp shadows, shadow bands, tiny crescents projected through pinhole gaps. We talked about the diamond ring and Baily's Beads and sunspots and prominences and then we stopped talking to watch. At totality everything happens so quickly. Three minutes seems even shorter than it is.

The birds were flying around looking for a place to roost. Wesley Jacobs, who had seen the 1999 eclipse in rural Turkey, said cultural aspects of this eclipse were what moved him. As the sky became dark and eerie, the villagers began shouting. They shouted and we shouted with them. The clamor of human admiration was with us until the sun outshone the diamond ring.

Several thousand eclipse chasers selected Zimbabwe as their destination in southern Africa, where the path of totality crossed Angola, Zambia, Zimbabwe, Mozambique and Madagascar. *Astronomy*'s tour was organized in a different way than most. Our 100 travelers chose from several itineraries and made up eight distinct groups.

Bonnie Gordon's Trip: On June 14, 25 of us landed on Spurwing Island, where the first group began its trip. It was here that almost everyone with us caught at least a glimpse of a single, rare black rhino. We also tracked a pride of lions during the three days of our visit; many visitors watched the lions as they attempted to round up a nearby herd of impala.

Matopos features balancing rocks in all shapes, including this "woman-with-child." Becky Talcott



The hippos, most deadly of African animals, were plentiful in Lake Kariba. Peter Sutter

Wildebeests, it is said, are created of the spare parts of other animals. Peter Sutter

During much of our time on Spurwing, we were the only guests, living in fancy tents and cabins. We took meals together and were hosted by perhaps 50 workers, including cooks, waiters, maintenance staff, and game guides who must train for certification for three years. Spurwing Island, on Lake Kariba, a lake formed by damming the Zambezi River, was the most remote of sites visited by our group — which included two travelers in their mid-eighties and an eight-year-old boy. The game drives at Spurwing were on the mainland, where we traveled by boat each morning at dawn.

When we flew into Spurwing, we could check only soft-sided luggage weighing less than 22 pounds. We could carry on cameras and binoculars, however, and Thomas Grimshaw brought his 8-inch Schmidt-Cassegrain telescope on one of our 12-passenger planes, carrying it in his lap. Every night at Spurwing we doused the lights, and Tom shared his scope on the pier. Our guides were particularly attentive, staying out late to enlarge their natural universe.

We moved to Hwange Safari Lodge from Spurwing Island and there we stayed in a large hotel that resembled a Hilton, but for the watering hole that sat at the edge of the grounds drawing impala, sable, kudu, baboons, monkeys, elephants, wildebeests, warthogs (some of which we tasted at dinner), and even lions.

My biggest game-viewing moment came on the first drive of our visit to Hwange. Our driver, Rafael Ndlovu, had spotted a zebra, which had escaped from a snare with a wire dragging from its neck. He asked if we'd like to go out and meet an animal rescue team, watch it tranquilize the zebra with a dart gun, and help free it from the wire. We met the rescuers near an open field. The required tranquilizer would kill a human in 30 seconds.

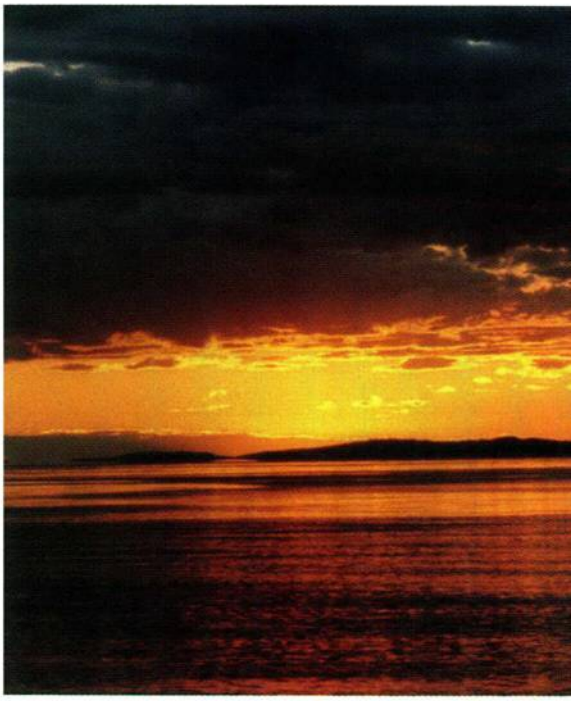
The gunman loaded the dart into his airgun, climbed into our open Land Rover, and off we went among wildebeests and zebras. It took some time to get near enough to the edgy zebra, but we did, and the shooter sent the dart into her hip on his first try. When she finally fell to her knees, all the humans jumped from the rover and ran to her aid. Rafael put a shirt over her head so she wouldn't be too frightened. The darts were pulled and the wire was cut; it had done little damage. Once the tranquilizer was reversed with an antidote, we moved away from the zebra quickly and in only a moment, she was up, running. By the time she rejoined the herd that waited for her near the field, she was galloping smoothly.

No question we had some adventures: Stephen Robinson's family arrived in Harare ahead of the tour and went off in a rented car to see the archaeological ruins of Great Zimbabwe. On their way, the car hit a kudu — something in the antelope family about the size of an elk. Alas, the kudu died and so did the car. Near twilight, rescuers came in the form of a Lutheran missionary and some of his flock. The missionaries, on their way to the closest village to buy meat, now had a free kudu. They butchered it before carrying the Robinsons to safety.

Rich Talcott's Trip: For the 14 intrepid adventurers in our group, day one of our safari was a study in patience. We had just spent more than nine hours traveling from Harare to the lowveld in southeastern Zimbabwe. Our cramped minibus had to observe a speed limit of 80 kilometers per hour (about 50 mph), and widespread "diesel queues" — brought on in part by the government's decision to raise fuel prices by 70 percent that very week — didn't speed the journey.

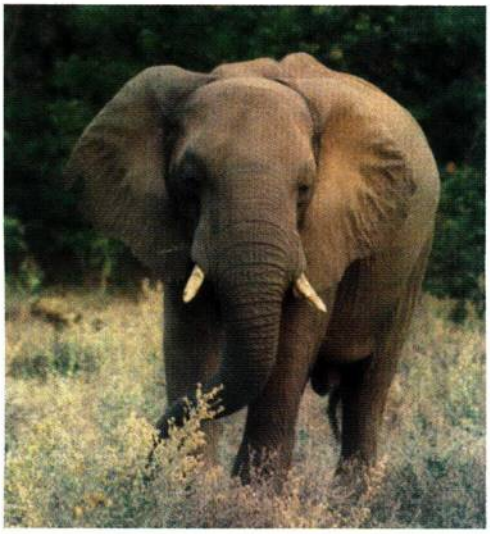
Darkness was descending as we arrived at Mahenye Safari Lodge, located on Geyseni Island in the Save River just outside Gona-re-Zhou National Park. After dinner, we walked down to the river's edge and beheld the glittering Milky Way stretching from Vela through Crux and Centaurus and on to Sagittarius. Shining like a ruby at the center of these celestial gems stood Mars, high in the sky and glowing brighter than at any time in the past 13 years. The chattering of Egyptian Geese and the distant trumpeting of an elephant reinforced the alien feel of this exotic land- and skyscape.

The next morning we clambered aboard a small boat and a local villager used a long pole to push us across the river to the park. Our two guides, Japhet Diza and Stephen Midzi, each took seven people on a Land Rover and set out in search of Gona-re-Zhou's four-legged residents. The vast park covers 5,000 square kilometers and is widely regarded as Africa's wildest.



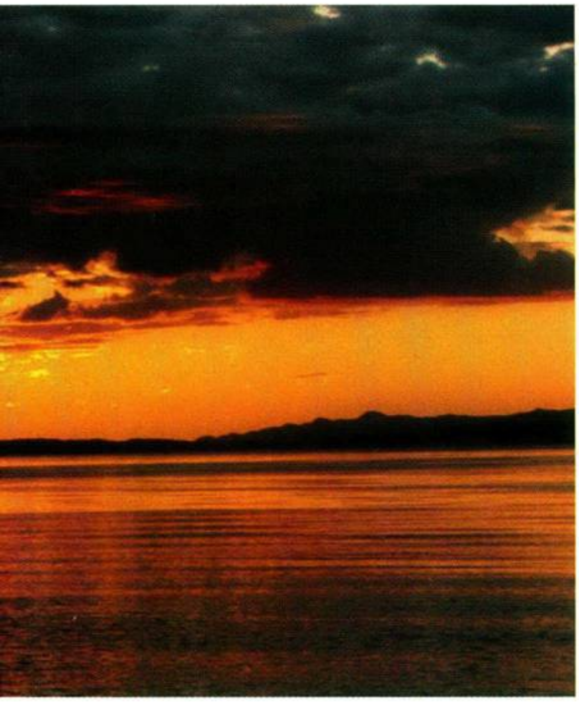
An animal rescuer reverses the tranquilizer shot into a zebra to subdue her while a snare was removed from her neck.

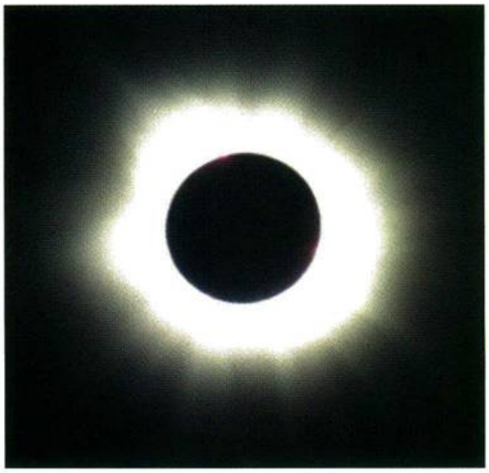
Peter Sutter



Some of us tracked elephants on foot and actually succeeded. We were terrified, though, when they turned and came at us.

Peter Sutter





Above left: Claims of the beauty of African skies have not been exaggerated. Peter Sutter

Above: Rushinga's villagers were festive and animated during the first eclipse of the millennium. Peter Sutter

Left: At totality the eclipse left all with the view of a nearly perfect corona. Michael Stegina

After two days at Gona-re-Zhou, in which we approached on foot to within 150 feet of a dozen elephants, it was off to Great Zimbabwe. These massive stone structures, built between A.D. 1200 and 1500, form the largest ancient stone structure in sub-Saharan Africa. The site gave its name to the country when Zimbabwe achieved independence from Great Britain in 1980.

From Great Zimbabwe, we traveled to Matopos National Park. While passing through Bulawayo, Zimbabwe's second largest city, the gear shift on the minibus broke. After jerry-rigging a temporary fix, we continued on with the use of only second and fourth gears. Unfortunately, the gear shift was not the last thing to break that day.

After arriving at Big Cave Camp late in the day, we opted for a quick hike to see some bushman cave paintings. Normally the walk would have been fine, but this happened to be the only day we saw rain the entire trip. While descending across some rain-slickened rocks, Mary Brown slipped and fractured her ankle in two places. In the deepening twilight, with only two small flashlights and a mile of trail to navigate, we quickly devised a plan.

We sent two people ahead to get help while the others took turns carrying Mary through the woods. As the ungainly caravan marched on, a nearby troop of baboons howled, no doubt mocking the humans' predicament. Just as one of the flashlights gave out, help arrived. With the help of powerful flashlights and strongly muscled workers from the camp, the last half of the trip went much more smoothly. Mary was whisked to the local hospital, where the doctors inserted a pin into her ankle. Through it all, Mary seemed more concerned with how the accident affected the group than with her own condition. (By the way, she's recovering quite nicely back home in Wales.)

After the events of the previous night, the next day's journey to the park seemed rather pedestrian. Matopos is best known for its landscape of balancing rocks, perched in precarious and intriguing shapes. It also holds the largest concentration of endangered rhinos left in the world. We saw three white rhinos resting just 50 feet from the road, as well as hippos, giraffes, and several species of antelope.

Our group closed with a visit to Victoria Falls. Far larger than America's Niagara Falls, Victoria Falls remained cloaked in the mists of its own fury. The power of the falls throws up so much mist that it's impossible — except near the end of the dry season in September and October — to get a clear view. Glimpses of the cataracts are about the most you can see. For arguably the country's grandest spectacle, it proved a little disappointing. But it gives an incentive to make another trip to Zimbabwe. How does the total eclipse in December 2002 sound? ■

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sky Show

october

Saturn and Jupiter rise before midnight and two comets are best at dawn.

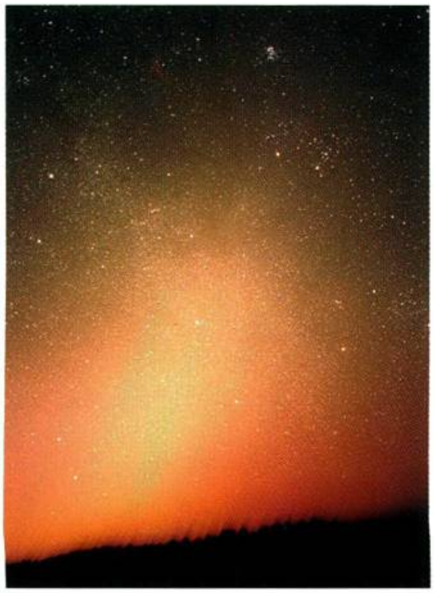
by Martin Ratcliffe and Alister Ling

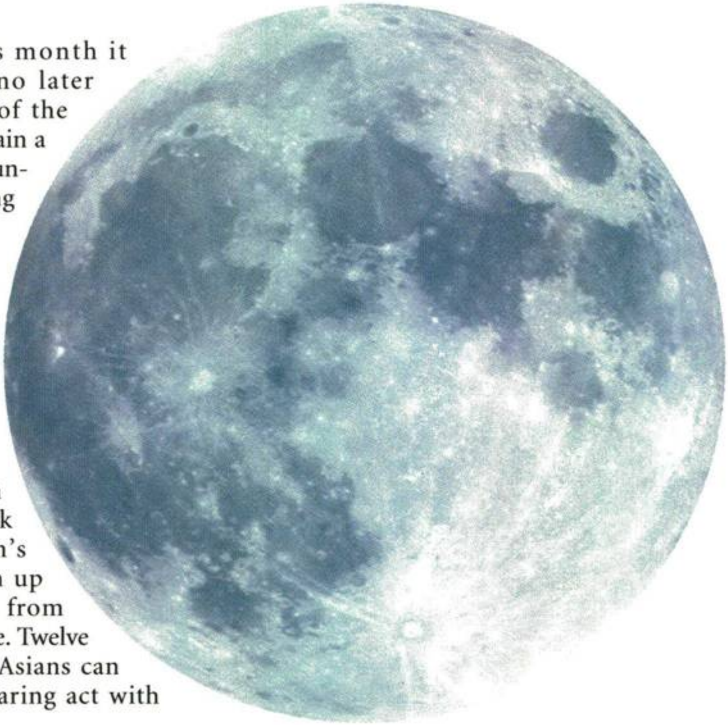
▶ Autumn is one of the best observing seasons around the world. In the Northern Hemisphere, the longer nights often team up with great transparency. Rising prominently in the eastern sky this year, the gas-giant planets shine like beacons of a friendly harbor. The sparkling Pleiades star cluster first heralds golden Saturn with its magnificent rings, followed an hour later by Jupiter with its swirling cloud belts and dancing Galilean moons.

The harvest moon rules the evening sky at the start of the month, bathing the landscape with its golden glow. For the next couple nights the moon travels almost as much north as it does east, so that it rises at nearly the same time each night. A most satisfying sight is the yellow-pink moon floating gracefully above a busy harvest field lit in sunset glow. Here's a simple rule for snapping a successful picture: Do it before sunset, otherwise the brilliant moon will be overexposed relative to the scenery. This month it means shooting no later than the evening of the first. You can try again a few minutes after sunrise on the morning of the 3rd.

The lunar action continues on Saturday night, October 6/7, when the moon passes across the northern edge of the sparkling Hyades star cluster in Taurus. Stars wink out as the moon's edge gobbles them up and then pop out from behind the dark side. Twelve hours later, lucky Asians can watch the disappearing act with Saturn instead.

Taurus begins to climb above the twilight glow on these autumn mornings. Ronald E. Royer





The harvest moon graces the evening sky at the beginning of October. Alan Dyer

Many readers know that the lunar month is about 29.5 days, but thanks to the benchmarks of Saturn and Jupiter, you will be able to see that one orbit takes only 27.3 days. Use Jupiter as an anchor on the evening of the 8th, when it lies to the left of the moon. By Sunday, November 4, the moon is just short of its starting mark, and only 27 days have elapsed.

By a nice coincidence on the 8th, Jupiter is 10° away from the moon. This angle is the apparent width of your fist when held out at arm's length. It appears as if you could fit 20 moons between the two bodies. See if you can find Jupiter in binoculars after sunrise the next morning, using the moon as a guide. Or, try it with the naked eye.

The blazing morning star Venus greets those who are awake by 6:30 A.M. As a special reward for early risers, swift Mercury climbs past Venus in the last week of October. It's not often you get a nice photo op of this pair only one moonwidth apart, let alone for 5 days in a row. The crescent moon joins Venus on the 14th and 15th.

In complete contrast, Mars has relinquished its summertime glory. It's still bright enough to be inviting, yet the telescope reveals its ocher disk as a small, blurry, disappointing sight to all beginners.

The children of Halley's Comet are raining down on Earth. As the speedy dust grains slam into Earth's upper atmosphere, they leave streaks marking the Orionid meteor shower, which peaks during the weekend of the 20th. In the darkness of a country sky these so-called falling stars add a touch of delight to all observing sessions. Stay up until dawn to track down two comets, Borrelly and WM1 LINEAR. WM1 is predicted to crest into naked-eye visibility by December.

October 2001

2 Full moon is at 9:49 A.M. EDT

7 The moon passes 0.5° north of Saturn, 3 P.M. EDT (page 63)

9 The moon passes 1.4° north of Jupiter, 8 P.M. EDT

10 Last quarter moon is at 12:20 A.M. EDT

12 Mars is at perihelion (128.4 million miles from the sun), 3 A.M. EDT

13 Asteroid Laetitia is at opposition, 11 A.M. EDT
Mercury is in inferior conjunction, 10 P.M. EDT

14 The moon is at perigee (224,849 miles from Earth), 7:02 P.M. EDT
The moon passes 4° north of Venus, 10 P.M. EDT

16 New moon is at 3:23 P.M. EDT

21 Orionid meteor shower peaks (page 64)

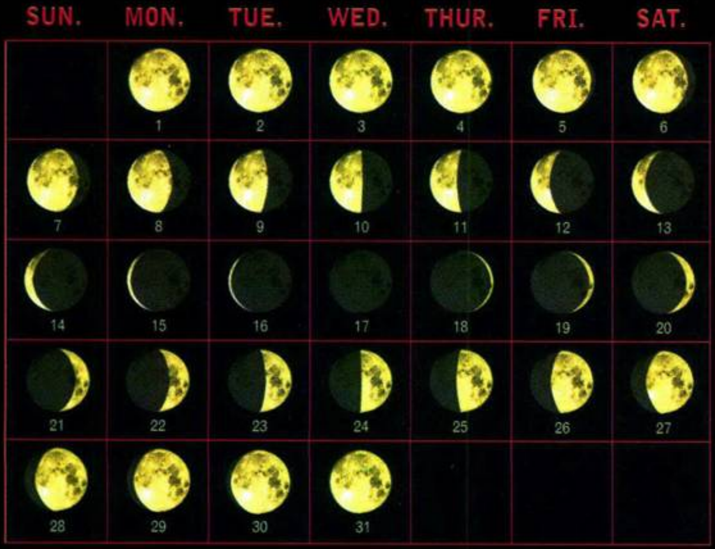
23 The moon passes 0.1° south of Mars, 4 P.M. EDT
First quarter moon is at 10:58 P.M. EDT

24 The moon passes 3° south of Neptune, 8 A.M. EDT

25 The moon passes 3° south of Uranus, 1 P.M. EDT

26 The moon is at apogee (251,615 miles from Earth), 4:13 P.M. EDT

29 Mercury is at greatest western elongation (19°), noon EST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MON.
TUE.
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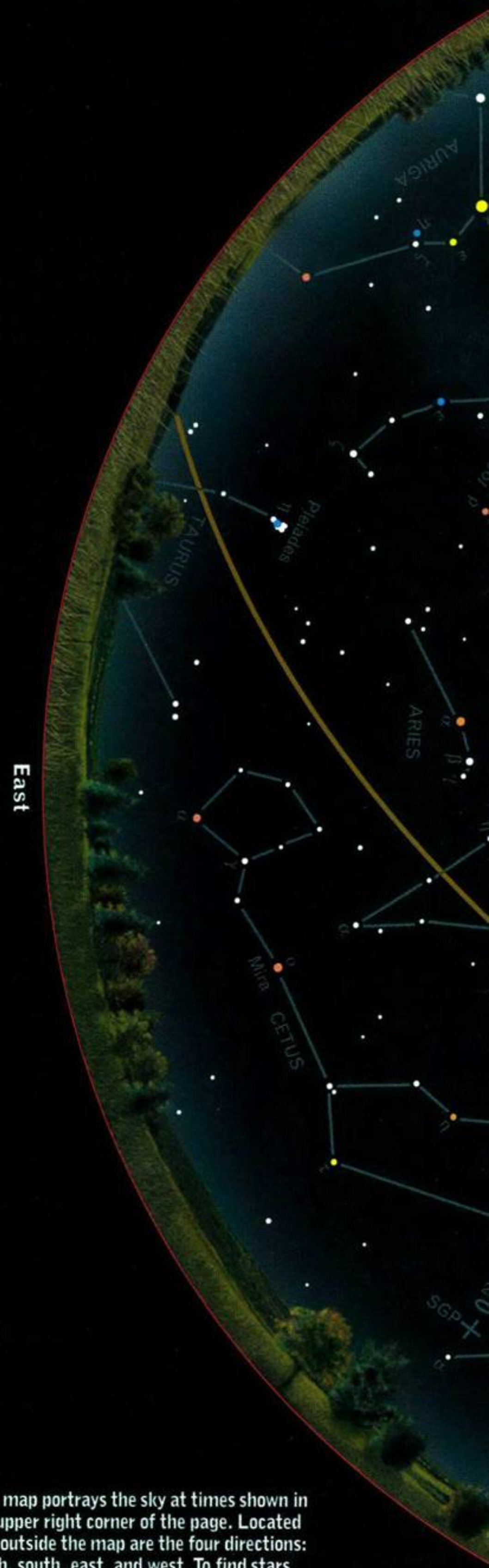
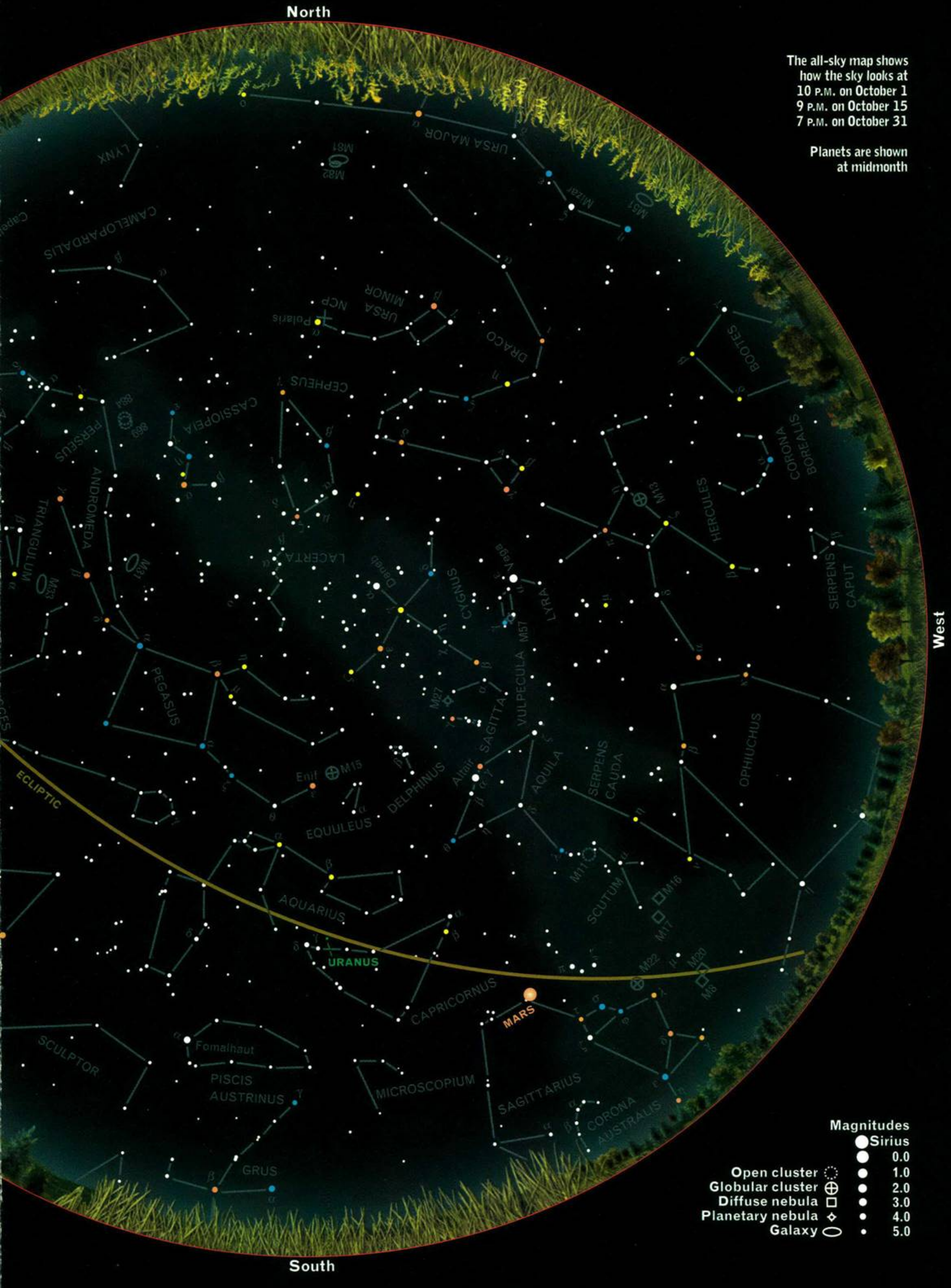

East
AURIGA
TAURUS
Pleiades
ARIES
Mira
CETUS
SGP

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

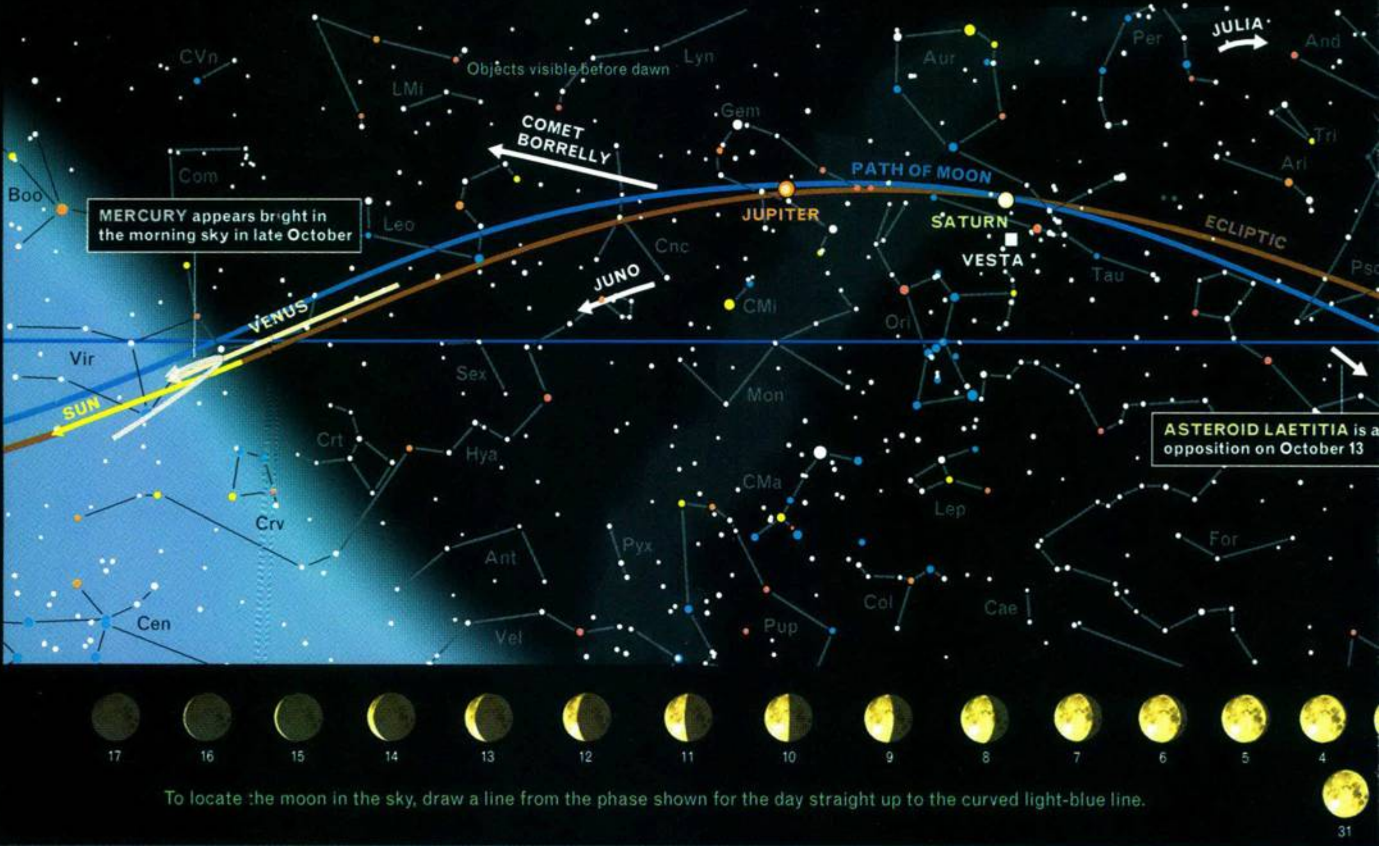
The all-sky map shows
how the sky looks at
10 P.M. on October 1
9 P.M. on October 15
7 P.M. on October 31

Planets are shown
at midmonth


North
South
West
URSA MAJOR
M81
M82
Mizar
M51
LYNX
CAMELOPARDALIS
URSA MINOR
NCP
Polaris
DRACO
BOOTES
CEPHEUS
CASSIOPEIA
884
869
PERSEUS
ANDROMEDA
TRIANGULUM
M33
M31
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
SERPENS CAPUT
PEGASUS
VULPECULA
M27
SAGITTA
Altair
AQUILA
SERPENS CAUDA
OPHIUCHUS
Enif
M15
DELPHINUS
EQUULEUS
ECLIPTIC
AQUARIUS
URANUS
M11
SCUTUM
M16
M17
M22
M20
M8
CAPRICORNUS
MARS
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
SAGITTARIUS
CORONA AUSTRALIS
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects



CVn
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Objects visible before dawn
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Gem
Aur
Per
JULIA
And
Tri
Ari
Com
Boo
COMET BORRELLY
Leo
Cnc
JUPITER
PATH OF MOON
SATURN
VESTA
ECLIPTIC
Psc
Tau
JUNO
CMi
Ori
VENUS
Vir
SUN
Sex
Mon
Crt
Hya
CMa
Lep
Crv
Pyx
Ant
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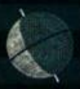
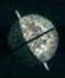
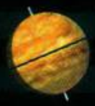
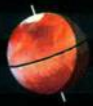
MERCURY appears bright in the morning sky in late October

ASTEROID LAETITIA is a
opposition on October 13

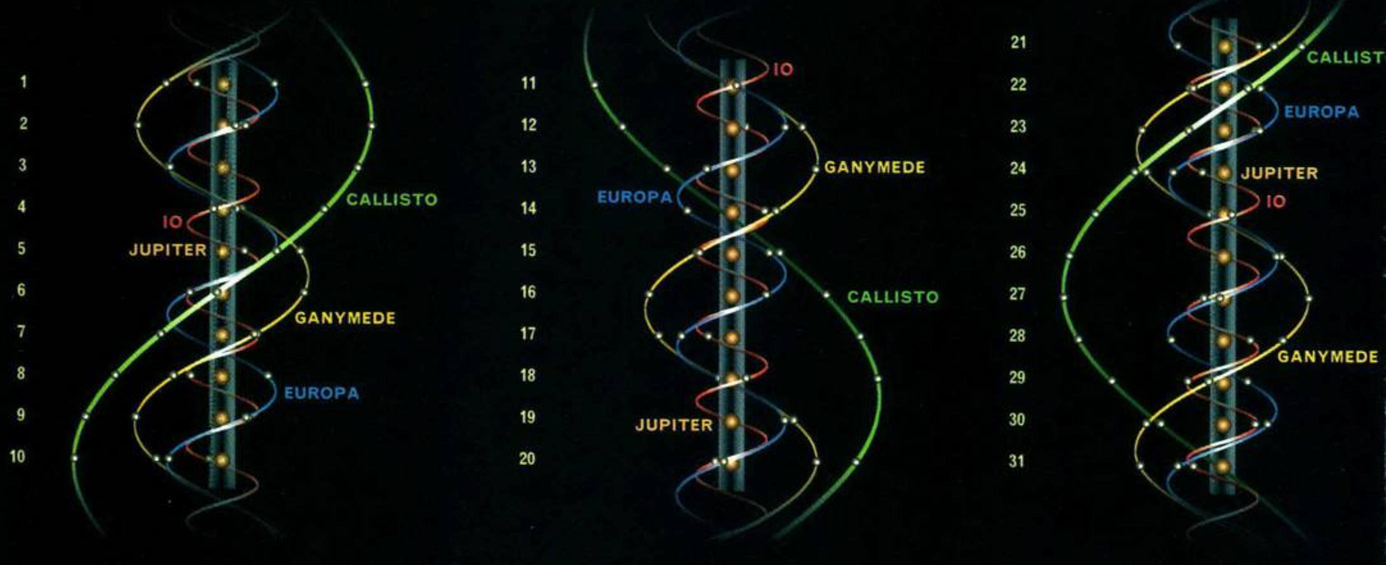
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

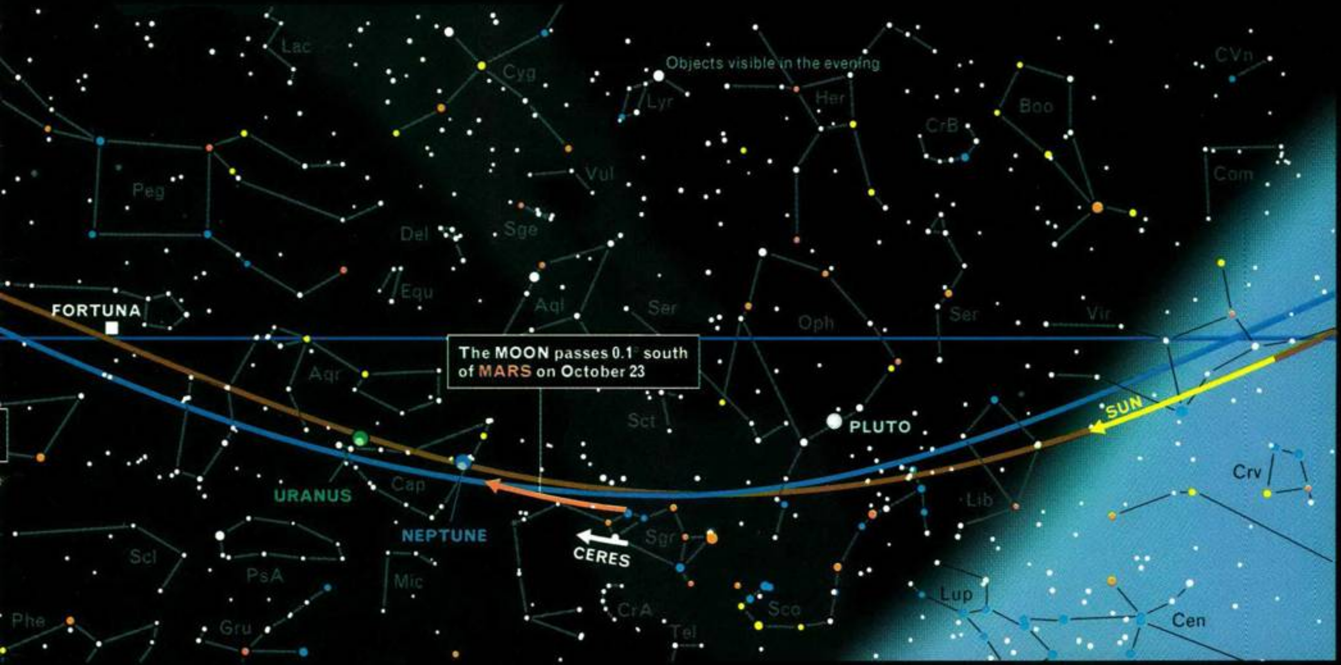
PLANETS	**MERCURY**	**MERCURY**	**VENUS**	**MARS**	**MARS**
Date	October 1	October 31	October 15	October 1	October 31
Magnitude	0.7	−0.6	−3.9	−0.4	0.0
Angular Size	8.7"	6.6"	10.9"	10.7"	8 8"
Illumination	31%	62%	92%	85%	85%
Distance (AU) from Earth	0.775	1.019	1.533	0.875	1.062
Distance (AU) from Sun	0.406	0.324	0.719	1.382	1.384
Right Ascension (2000.0)	13h44.9m	13h14.4m	12h00.1m	18h55.8m	20h20.0m
Declination (2000.0)	−14°46'	−5°33'	1°38'	−25°43'	−21°44'

Jupiter's Moons

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.


Lac
Cyg
Objects visible in the evening
Lyr
Her
CrB
Boo
CVn
Peg
Vul
Com
Del
Sge
Equ
Aql
Ser
Oph
Ser
Vir
FORTUNA
The MOON passes 0.1° south of MARS on October 23
Aqr
Sct
PLUTO
SUN
Crv
URANUS
Cap
Lib
NEPTUNE
CERES
Sgr
Scl
PsA
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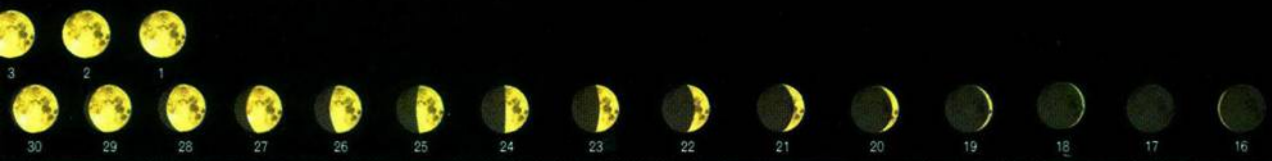
Sco
Lup
Cen
Phe
Gru
Tel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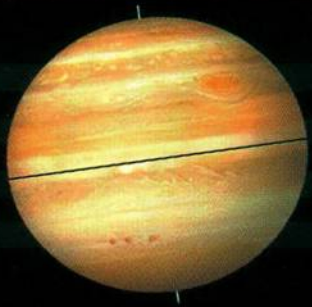
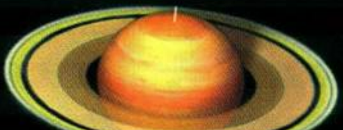
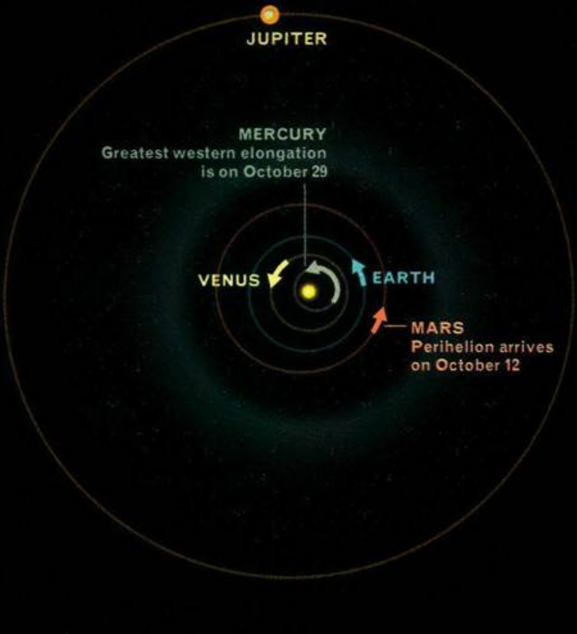


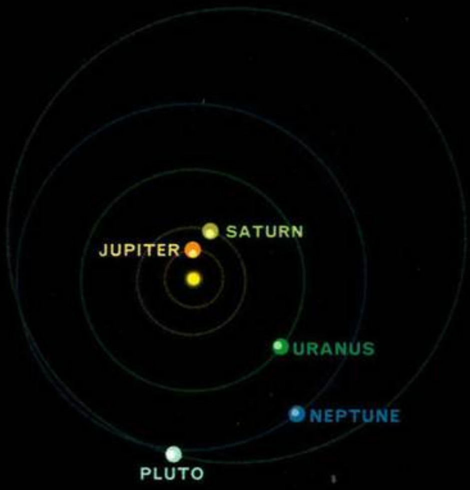


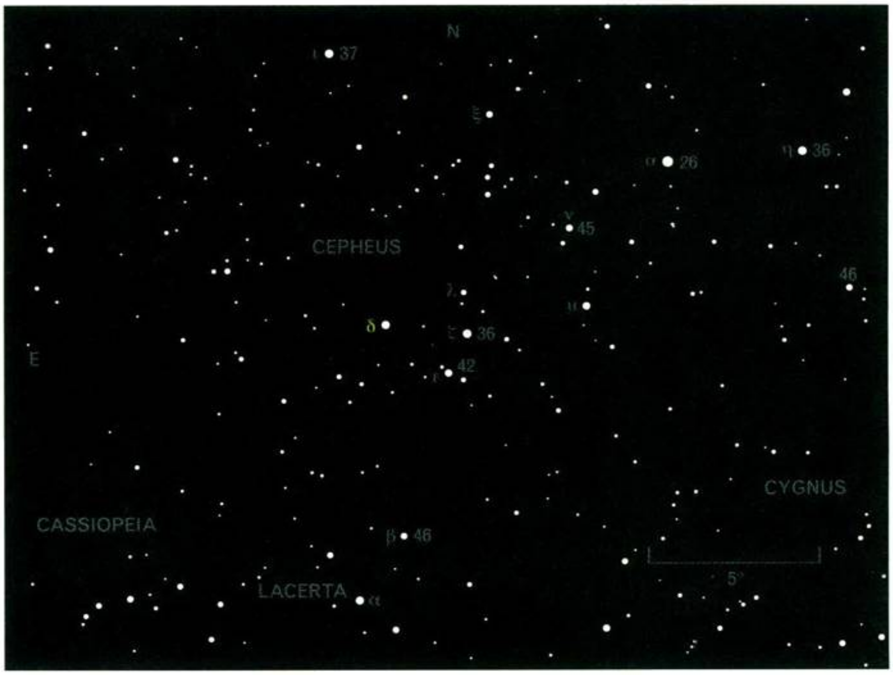
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
October 15	October 15	October 15	October 15	October 15
−2.3	−0.1	5.8	7.9	13.9
40.0"	19.7"	3.6"	2.3"	0.1"
99%	100%	100%	100%	100%
4.932	8.436	19.475	29.837	31.034
5.142	9.072	19.982	30.098	30.434
7h05.5m	4h54.3m	21h34.5m	20h33.3m	16h52.4m
22°26'	20°43'	−15°12'	−18°40'	−12°30'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
MERCURY
Greatest western elongation is on October 29
VENUS
EARTH
MARS
Perihelion arrives on October 12


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO



A Galactic Ruler

Arcing high overhead, King Cepheus commands the northern sky, if only by title. His 3rd- and 4th-magnitude stars can't compare to the jewels of Queen Cassiopeia or to the luminaries of Cygnus, but his outer spiral arm kingdom contains one of the most important stars in our galaxy.

Close to the foundation of the cosmic distance scale, Delta (δ) Cephei pulses with a majestic, diagnostic beat that can be followed with the naked eye. The remarkable rule that brighter Cepheids have predictably longer cycles than fainter ones was discovered by Henrietta Swan Leavitt in 1912. When astronomers extrapolate using the simple law that farther objects are fainter, it means that a Cepheid's pulse and brightness reveal its distance.

Hubble himself first measured Cepheids in the Andromeda Galaxy, and today the telescope that bears his name follows the heartbeat of Cepheids in the Virgo Cluster of galaxies. With each leap into deep space, our cosmic yardstick grows. This ruler's fundamental tick marks are inscribed by the Cepheids.

Discovered more than 200 years ago by John Goodricke in 1784, Delta Cephei's variability is easily followed in binoculars or with the naked eye. It rises fairly quickly to a maximum magnitude of about 3.6, then fades over the next four nights to about 4.3. Remember that larger magnitude numbers mean fainter objects. You can readily notice the change because nearby Zeta (ζ) and Epsilon (ε) Cephei bracket Delta's brightness swings.

To monitor its regal heartbeat, you can use the accompanying chart. (Magnitudes are shown without decimal points to avoid confusion with stars.) Every night, estimate Delta's brightness relative to the control stars and within a few weeks you should be ready to guess its period.

Gas, Dust, and Star Clusters

Gracing each spiral arm of a pinwheel galaxy are hundreds of nebular cocoons, molding cold, dark, hydrogen gas into a brilliant life. Most stellar nurseries create clusters of stars, like those at the center of the famous Orion and Rosette nebulae. The outer spiral arm flowing behind the stars of southern Cepheus has been very active. You may not know it well because it lies farther away from us than the prominent Orion, Sagittarius, and Carina arms.

An 8- or 10-inch scope under the dark of a country night will reveal a host of fascinating objects between Cygnus and Cassiopeia. A guide such as *Uranometria* or the *Millennium Star Atlas* is indispensible for navigating across the stardust-rich fields. Several star clusters are still partly shrouded in their birth robes, such as NGC 7380 and IC 1470. The grandest of all is IC 1396. Six times larger than the apparent size of the moon, it spans nearly 3°.

IC 1396 is very prominent on wide-field images of the northern Milky Way. In fact, if you hold up a narrowband nebula filter in front of a binocular eyepiece, you will be able to see it. One night, with a 4-inch Astroscan and an O III filter, I spent a couple hours tracing out its huge shape and picking out the dust and gas patches. These dark nebulae absorb so much light that the background stardust is completely erased, as in the case of Barnard 161 (B161). Others, from the Lynds catalog, are not as opaque, but easier to see because of their larger size.

IC 1396 in Cepheus ranks among the finest emission nebulae in the sky. George Greaney

Treat yourself to a pleasurable trip by scanning the Cepheus Milky Way with binoculars. Lie down on a blanket with a soft support for your head and drink it all in.

Mars Bows to Saturn and Jupiter

Major planets are on display after midnight during October, while **Mars**, now tiny through most telescopes, lingers in the evening sky. The daily rotation of Earth shows Mars passing east to west across the sky and the planet sets shortly after midnight. The nightly path of Mars against the background stars, however, is swiftly eastward. October opens with Mars standing close to Sigma (σ) Sagittarii, also known as Nunki, in Sagittarius. By October 25, Mars has moved into Capricornus and stands a mere 40' south of the globular cluster M75.

Through a telescope Mars still exhibits a disk about 10" across, allowing martian features to be seen through an 8-inch scope or larger. Mars reaches perihelion (closest point to the sun) in its orbit on October 12, and at the same time the distance between the Red Planet and Earth increases quickly, passing through one astronomical unit (93 million miles) on October 21. During October, Mars fades from magnitude –0.4 to magnitude 0.0.

Saturn rises in the late evening, centered in Taurus the Bull. Close to midnight the planet will be well clear of the horizon and visible in the southeast sporting its magnificent ring system and retinue of moons. A spectacular event occurs early in the morning hours of October 8 for observers across parts of Asia and northern Japan, when the moon occults Saturn. This event is worth watching through telescopes and documenting on film. Watching the edge of the moon slowly advancing over the rings and disk of Saturn is truly memorable. The event occurs in daylight for observers in Alaska, and since the path of visibility occurs across the International Date Line, the event takes place on October 7 at about 11 A.M. local time in Anchorage, Alaska. American observers only have to wait until December 1 to view such an event.

On the evening of October 7, the moon stands 4.5° west of Saturn. So what is a degree, you might ask? A degree (°) is a measure of angle. A full circle has 360°. A full moon measures half a degree across, or 30 arcminutes, as does the sun. Degrees can be divided into 60 arcminutes, and each arcminute (') can be split into 60 arcseconds, with one arcsecond (") representing one three-thousand-six-hundredth of a degree.

You can use your hand and an outstretched arm as a useful measure for larger angles. At arm's length, your forefinger spans about 1°, a clenched fist covers 10°, and your fingers spread apart from thumb to pinkie finger span roughly 20°. The two stars that are the pointers in the Big Dipper stand 5° apart, and since it is always visible from the Northern Hemisphere it's a useful guide for angular measurements across the sky.

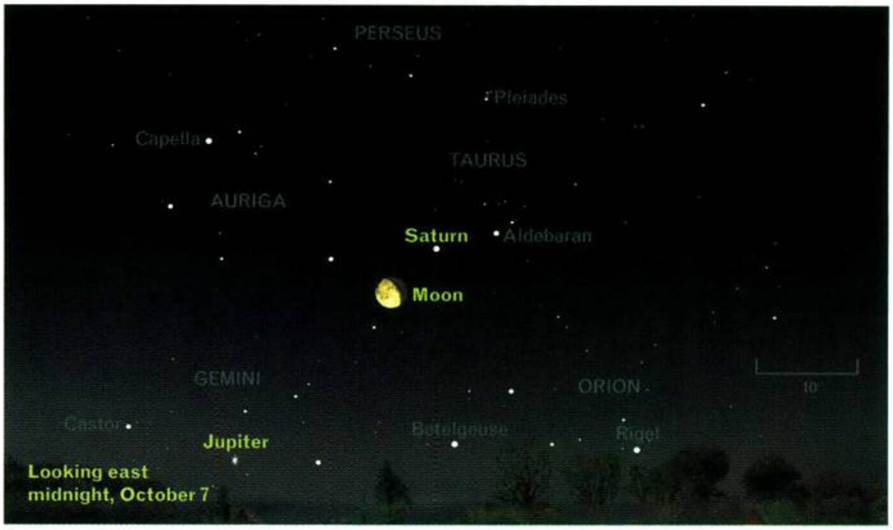
Late in the evening of October 6, the 0.5°-wide moon passes through the northern region of the 3°-wide star cluster in Taurus called the Hyades. The moon will cover, or occult, many of the cluster's stars in succession. Timing these events is an adventure in itself, with a number of them occurring over a few hours of one evening. Larger telescopes will show many fainter stars being occulted. The brightest star to be occulted on this night is the 3.5-

The moon and Jupiter pass through Taurus on April 9, 1989. Ivan Dryer magnitude star Epsilon (ε) Tauri. For the center of the United States this event occurs at about 12:26 A.M. (October 7). The occultation is easily visible in binoculars. An easy way to time it is to use a camcorder with a zoom feature on a tripod and record the event. Time can be provided by a short wave radio tuned to WWV Fort Collins, Colorado, found at 5000 MHz and recorded directly onto the video tape. A modern camcorder can easily record a 3rd-magnitude star. Check the International Occultation Timing Association's website for up-to-date predictions for your city at lunar-occultations.com. In addition, the site provides detailed instructions on how to use a camcorder to record such events.

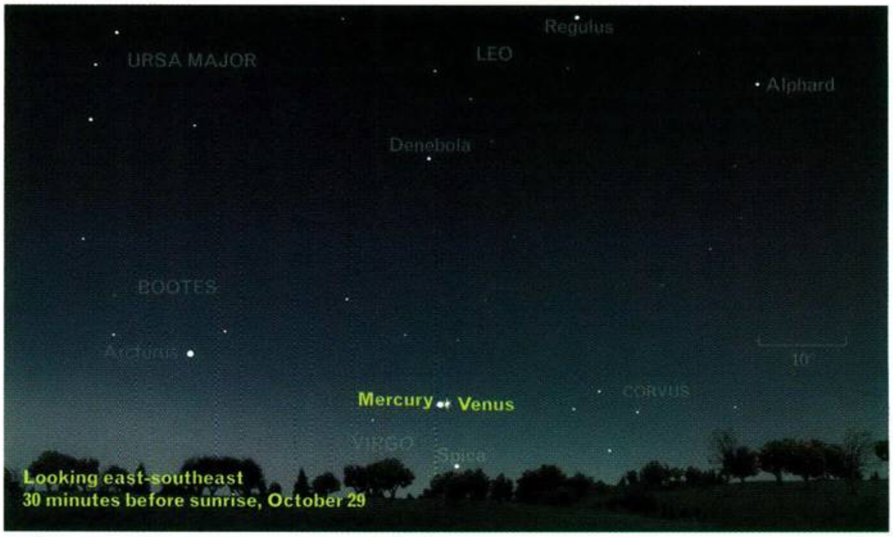
Returning to the planetary scene, **Jupiter** rises about two hours after Saturn. It shines at magnitude –2.3 in central Gemini, dramatically changing the appearance of the constellation. By dawn Jupiter lies more than 60° above the southern horizon. Jupiter is the finest planet for viewing through a telescope for two reasons. First, the tremendous belt and zone structure on the planet changes rapidly and can be followed through almost any telescope. Second, Jupiter's four Galilean moons perform an elaborate dance around the planet, occasionally passing in front or behind the giant orb. Many such occultations and transits occur this month (see Meteors and Moons).

Jupiter's apparent size is the largest of any planet and passes the 40"-diameter mark in the second week of October. The next five months represent an excellent time to become acquainted with the marvelous detail on Jupiter's disk. Jupiter's rapid rotation brings new features onto the visible face each hour. With Jupiter high in Gemini, some nights from late November to early next year will show an entire rotation of Jupiter in one night. The dark pair of equatorial belts span the equatorial zone where much of the turbulent action of the atmosphere takes place.

Venus shines at magnitude –3.9 and rises more than an hour before the sun in mid-October. Look for the crescent moon near Venus on October 15. Ten degrees separate the two objects early on October 14, with the slim crescent rising first and Venus lying directly below the moon. The following morning Venus rises first — try the challenge of spotting the extremely thin moon nearly 6° to the lower left of Venus. The moon will be 32 hours away from its new phase.



Looking east
midnight, October 7



Looking east-southeast
30 minutes before sunrise, October 29

As dawn approaches in late October, a fleeting appearance of **Mercury** occurs as the planet joins Venus in a spectacular conjunction. The pair is closest on the morning of October 29 when they stand just over one moon-width apart. The two rise shortly after 5 A.M. local time (note that daylight-saving time ends October 28) and lie in the direction of Virgo. If the sky is not too bright, Theta (θ) Virginis may be visible, forming a triangle with the two planets. During the following week, the two fall toward the sun's glow (in reality they are moving in their orbits around the far side of the sun). Try photographing this duo before the sky becomes too bright. Mercury brightens each day but the effect is counteracted by it rising later each morning, leaving it in a progressively brighter sky. Mercury glows at magnitude –0.5 on October 29, when it stands at its maximum elongation west of the sun (19°), and shines at magnitude –0.7 on November 2.

Meteors and Moons

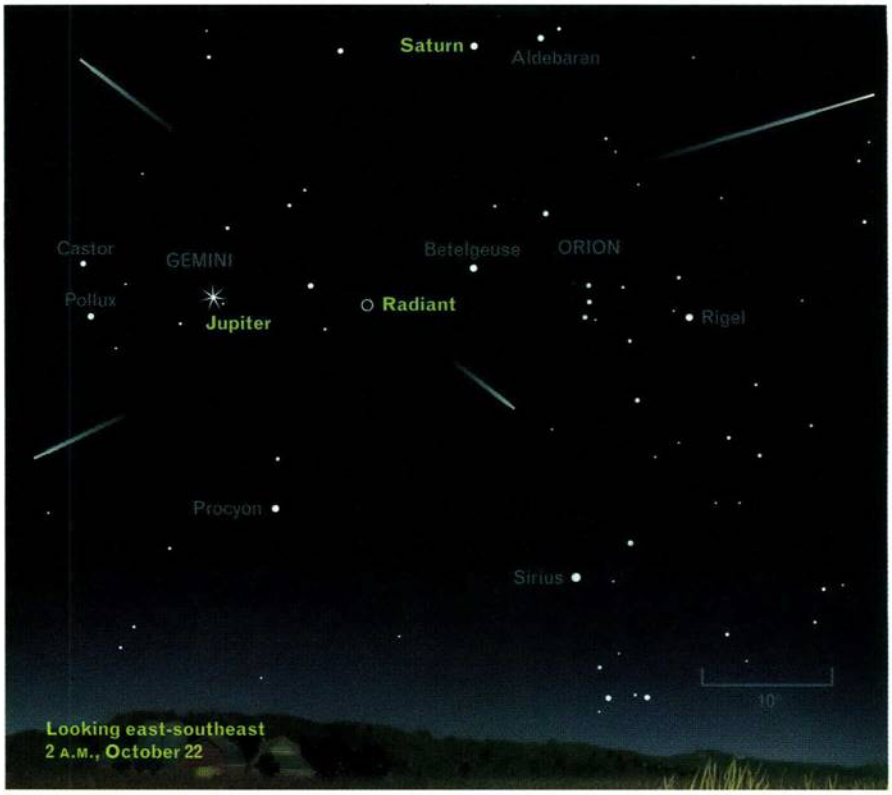
Here Come the Orionids

Halley, the most famous of all comets, is the progenitor of a stream of particles that causes the annual Orionid meteor shower. Earth plows through this cometary debris stream between October 2 and November 7. This year, with the moon a waxing crescent setting before 11 P.M., conditions are favorable for viewing. The peak of activity occurs on October 21. Near maximum the radiant lies near the "club" asterism in northeastern Orion and reaches a decent altitude before midnight.

Catch the Zodiacal Light

The dust that causes meteors pervades the whole solar system and lies generally in the plane of the ecliptic — Earth's orbital path around the sun projected onto the sky. At certain times of the year the ecliptic lies at a steep angle to the horizon, and shortly after sunset it is possible to see sunlight glinting off these particles as an extremely dim cone of light aligned with the ecliptic. This so-called "zodiacal light" is best seen from extremely dark sites and higher altitudes. In October the ecliptic lies steeply slanted from the horizon in the early morning.

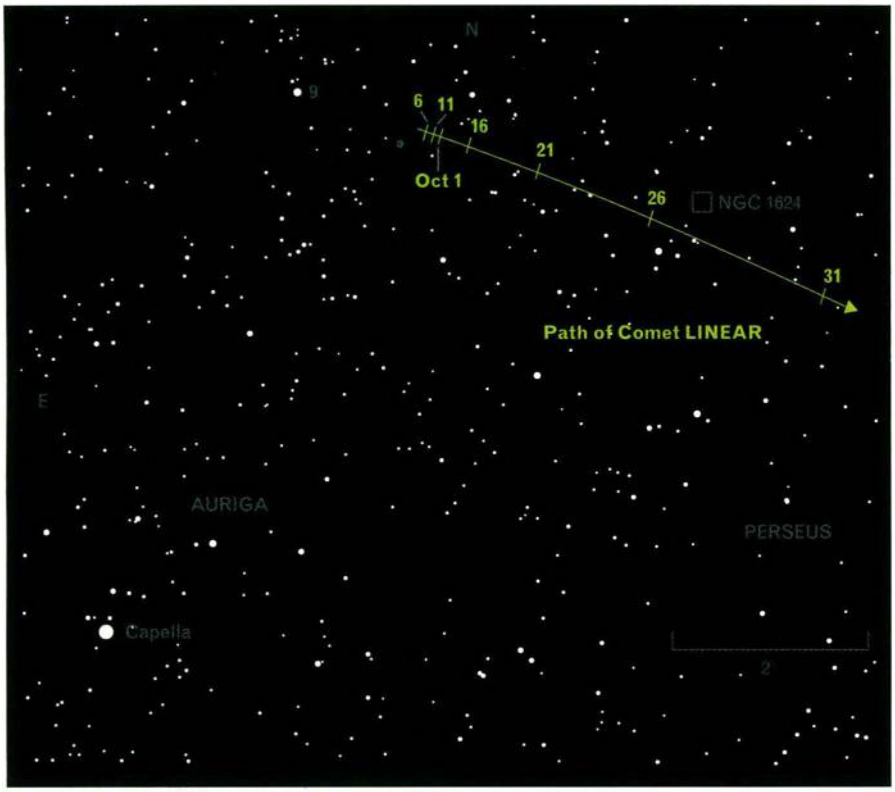
Plan to keep an eye on the eastern horizon about three hours before dawn during the two weeks after new moon on October 16. Look for a cone-shaped glow running up through Cancer and Gemini. The planet Jupiter will provide a good reference for the line of the ecliptic — simply draw a line in your mind's eye from Jupiter to the eastern horizon. The zodiacal light is very elusive and faint, but once seen, it's unmistakable. Within 90 minutes of sunrise the glow of dawn will begin to be evident on the eastern horizon, but the extended glow of the zodiacal light may linger. Unfortunately, anyone within a city or major town will never see this spectacle due to the heavy street lighting.

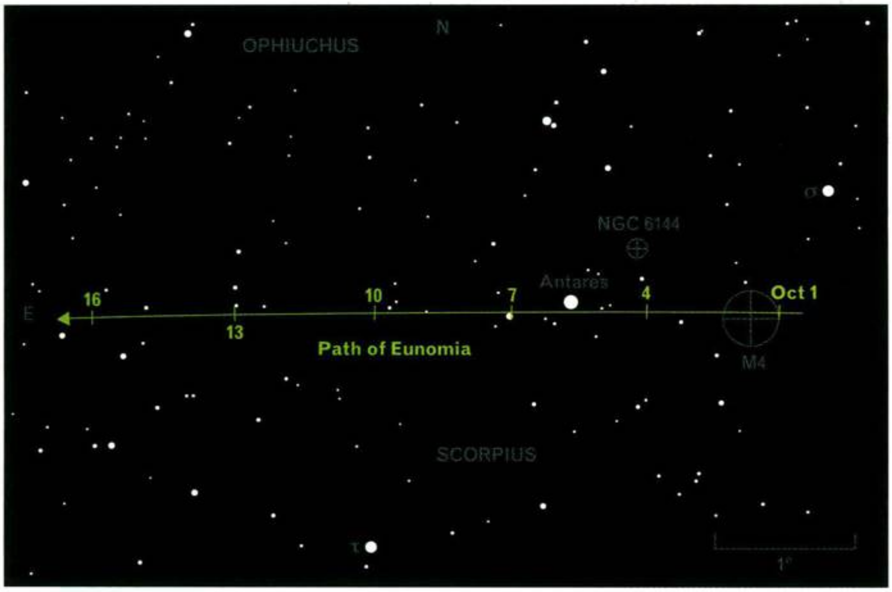


Look for the zodiacal light in the east before dawn on autumn mornings. Chris Cook

Galilean Satellites

Following the elaborate dance of Jupiter's four Galilean moons is an interesting adventure. Often both an eclipse and transit will take place as a satellite passes in front of the planet, or an occultation occurs when a moon passes behind. For example, two shadow transits occur during the early morning hours of October 9. At 4:12 A.M. CDT, the shadow of Europa can be seen as an inky black dot on Jupiter's visible face. Just two hours later, at 6:22 A.M. CDT, the shadow of Io begins its transit across Jupiter.





Shine on Borrelly, Hello LINEAR

If you're a comet fan, you have reason to smile. Two nice telescopic comets float in the morning sky, and one of them is slated to brighten into naked-eye visibility — if it can hold itself together. For a good view, wait until the middle of the month, close to the dark of the moon, and set up away from city lights.

Periodic Comet Borrelly continues its fine show but begins to fade as it pulls away from the sun. In a telescope, it should look like a smaller and fainter echo of the Andromeda Galaxy, sharp on the sunward eastern side and diffuse on the other. With a magnitude between 9 and 10, Borrelly will outshine any galaxy in the realm between Cancer and Leo. Compare it to NGC 2903, a dusty spiral galaxy near Leo's sickle. The stars Nu (ν) Cancri and Kappa (κ) Leonis will help you track it down.

Riding high atop the winter hexagon near Capella, new comet WM1 LINEAR approaches. LINEAR is an acronym for Lincoln Laboratory Near Earth Asteroid Research. Also discovered by this robotic telescope, S4 LINEAR was our big hope for a naked-eye comet last summer. It briefly reached its maximum as the Hubble Space Telescope caught it disintegrating.

We won't know for a few months if WM1 LINEAR is a featherweight like S4, or if it will brighten past our expectations. It should glow at about 9th magnitude this month. Watch it near the 27th as it slides only 20' south of the nebulous star cluster NGC 1624.

For both comets, take the time to observe them with a wide range of magnifications. Low power, 50x to 100x, reveals the overall shape and size of the tail. But you must use higher power, 150x to 250x, to get a closer look at the inner coma, where there may be some structure to see.

Rock Buzzes Globular Cluster

Observers across the southern states and Mediterranean should set their scopes on the big globular cluster M4 on the evening of the 2nd. Asteroid 15 Eunomia practically crosses the middle of this object, one of the sky's best globulars. Eunomia may be a tough find, because at magnitude 10.9 it's similar to M4's brightest stars. Begin observing as early as you can because the pair sets before 9 P.M. Unfortunately, northern observers may find M4 too close to the horizon for a decent view.

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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Set-up and break-down takes just minutes with this 4" Maksutov. Transportation is a breeze and its long focal length rewards the viewer with excellent planetary views, such as the Cassini divison of Saturn's ring or Jupiter's red spot. All of this at a very affordable price!

A 102mm Maksutov-Cassegrain design, 1300mm focal length (f/12.7), 6x26 correct-image finder scope, 25mm Sirius Plössl eyepiece (1.25"), 90° mirror star diagonal, soft carrying case, and EQ-2 mount.

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A 127mm Maksutov-Cassegrain design, 1540mm focal length (f/12.1), 6x26 correct-image finder scope, 25mm Sirius Plössl eyepiece (1.25"), 90° mirror star diagonal, soft carrying case, and a sturdy EQ-3 mount.

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Steel tube, 114mm mirror (f.l. 910mm, f/8), 1.25" R&P focuser, 6x30 achromatic finder scope, 25mm (36x) and 9mm (110x) Plössl eyepieces (1.25"), 5" flanged altitude hubs, CorrecTension Friction Optimization, built-in handle, dust cap. Weight: tube 9 lbs., base 8-1/2 lbs.

$199

SkyQuest XT6
The overachieving XT6 will show Jupiter's Red Spot, Saturn's Cassini Division, hundreds of clusters and nebulas, and galaxies tens of millions of light-years distant. Nicely portable and very affordable!

Steel tube, 152mm parabolic mirror (f.l. 1200mm, f/8), 1.25" aluminum R&P focuser, 6x30 achromatic finder scope, 25mm (48x) and 9mm (133x) Plössl eyepieces (1.25"), Moon filter, eyepiece rack, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap. Weight: tube 13 lbs., base 24 lbs.

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SkyQuest XT8
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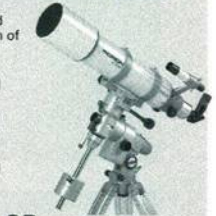

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The Next Generation

The NGT-6 equatorial split-ring mount mimics the 200-inch telescope at Palomar Observatory.

by Phil Harrington

Star Trek: The Next Generation brought us a new crew, new technology, and new missions. Now, thanks to Jim's Mobile, Inc. (JMI), of Lakewood, Colorado, the Next Generation Telescope line brings a new crew (intermediate observers) some new technology (an equatorial split-ring mount). The new (observing) missions are up to you.

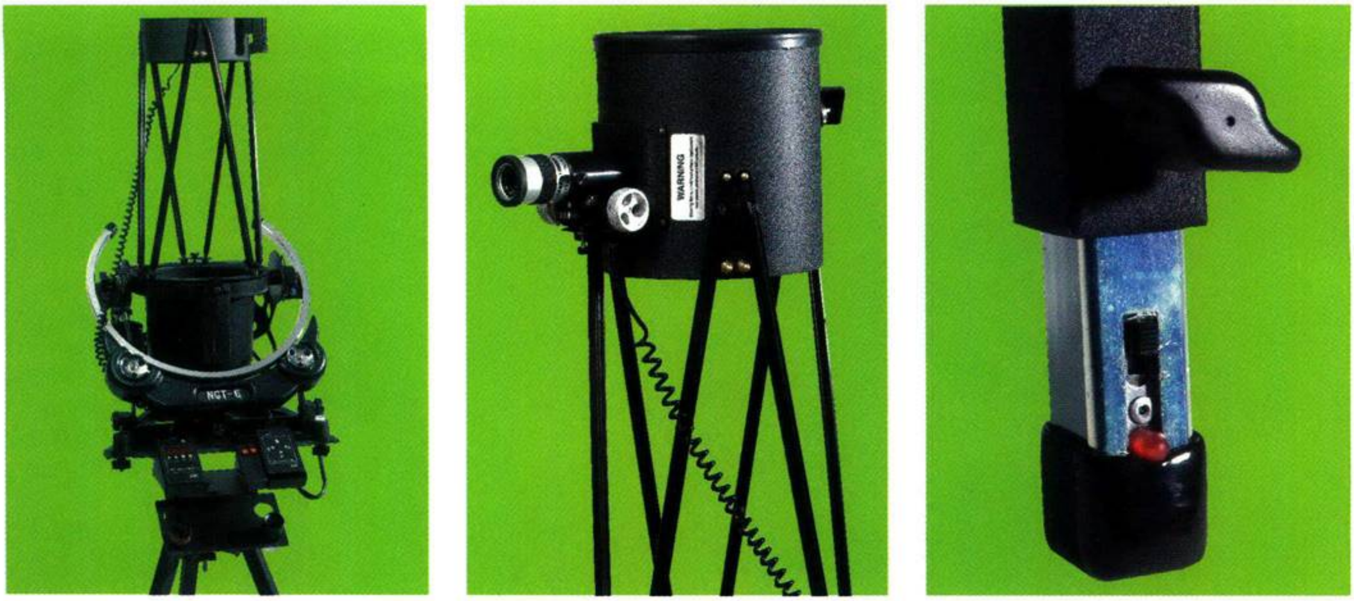
One-third the size of JMI's venerable NGT-18, the smaller NGT-6 (f/5) holds its own as a next-generation telescope. Its steering mechanism mimics that of the 200-inch Hale telescope at Palomar Observatory in California — only you can carry it around. Besides, it's undeniably cute.

Hey, cute is good, especially when it's functional. And this Newtonian-style telescope is nearly an ideal instrument. Its aperture is large enough to spot planetary details as well as many distant deep-sky objects.

I borrowed an NGT-6 directly from JMI. The telescope arrived with all of the standard gear included in the $1,200 base price: a 25mm Plössl eyepiece; polar-alignment sight tube; Celestron Starpointer LED-style unity finder; and dual-axis, 9-volt DC clock drive with hand controller. Optional equipment included a black fabric light shroud, motorized focuser, a pair of 1.5-pound counterweights, NGC-microMAX digital setting circles, and the custom tripod mount.

Astronomy: All photos by William Zuback

NGT-6
NGC micro-MAX
JMI
JMI
NGT-6
NGC micro-MAX
JMI
JMI



Left to right: The NGT-6's split-ring equatorial mount mimics the mount of its famous larger cousin, the Hale Telescope at Mount Palomar; sturdy composite rods support the tub assembly and eyepiece; a flashing LED tripod tip keeps observers alert.

The NGT-6 sits on a split-ring equatorial mount that pivots in declination within a 14.75" drive ring, which rides on a pair of wheels. A clock-driven motor powers one of those wheels, which tracks the instrument in right ascension. If the design sounds familiar, it should; it operates just like the horseshoe-shaped mount drives for many professional telescopes in observatories around the world.

Another feature that the NGT-6 shares with many of the large observatory telescopes is its Serrurier truss arrangement. It's an open-tube design, like many large-aperture Newtonians. But while those larger instruments typically use aluminum pipes for the truss, JMI substitutes composite poles. Made from an amalgamate of one-third fiberglass and two-thirds nylon, the poles span between the primary mirror's tub assembly and the secondary mirror's nose assembly.

Tips and Tubs

Without a tripod, the NGT-6 stands 35 inches tall and weighs 26 pounds. Its compact size makes it easy to carry around. I recommend JMI's optional custom tripod. The tip on each square aluminum leg has a built-in flashing red LED; each is also capped with a protective rubber foot. This solid metal tripod not only features a large, triangular plate that supports the telescope's base and holds extra eyepieces, but it also holds the drive's hand controller as well as the display unit for the digital setting circles.

The NGT-6 arrived at my door in perfect collimation, which says something about the quality of the mirror's cell and the instrument's overall construction. If you need to adjust collimation, turn three bolts at the bottom of the mirror tub.

Speaking of the mirror tub, to get the instrument to balance properly, JMI adds a fairly massive, metal counterweight directly behind the mirror. While this sometimes causes the counterweight to radiate absorbed heat (which distorts image quality) into the optical path of the telescope, I saw no negative impact on images through the NGT-6. Indeed, these were some of the finest views I have ever seen through a 6-inch Newtonian.

I tested the NGT-6 during the winter, purposely taking the telescope out from a warm house into subfreezing temperatures to see how well it acclimates to the cold. Cool-down time averaged 40 minutes, typical for this size instrument. The winter also afforded me a good opportunity to test the NGT-6 while observing seasonal planetary and deep-sky treasures.

Alignment ranges allow for polar alignment from latitudes between 25° and 45° as well as the second range that spans 43° to 58° (either north or south latitude, since the drive is reversible). Use the hinged sight tube on the side of the mount to align to the celestial pole. The telescope's clock drive keeps the field centered on a target for about 30 minutes without recentering.

On to the star test — that tell-all inspection where a star image is brought slightly outside of focus, then compared to the same image slightly inside of focus. Sure enough, these star images were perfect, confirming the high quality of the NGT's made-in-the-Ukraine mirrors.

In order to gain access to the eyepiece when aimed at different points in the sky, the entire optical tube assembly rotates within the split-ring mount. Unfortunately, the tub ring on the NGT-6 model I tested was slightly bent, making rotation by hand uneven and difficult.

The Sky and the Limit

Moving to some favorite sky objects, I began with M42, the Orion Nebula. Using a 22mm Tele Vue Panoptic eyepiece (34x), the view was wonderful, with many subtle turns and twists of M42 interwoven among the stars that littered the field.

Switching to my 7mm Pentax XL eyepiece (109x), I concentrated on the stars in the Trapezium. The four brightest were easily resolved even at low power, but I was going for bigger game: the fainter fifth and sixth stars nestled within. Normally, these objects are reserved for 8-inch or larger reflectors or the fine optics of a refractor, but I could make out the fifth star using this NGT (the sixth remained elusive).

The view of M42 and the clarity offered by the dark, midwinter sky impelled me to push the little NGT to the limit. Swapping eyepieces for my

NGT-6
NGC micro-MAX
JMI
JMI

Above: Convenient placement of the electronic controls facilitates alignment and observing.

12mm Nagler (64x), and attaching a hydrogen-beta nebula filter, I swung the telescope toward the star Alnitak, the easternmost star in Orion's belt. Shifting just one degree to the south, I began searching for IC 434 behind the elusive Horsehead Nebula.

While easy to capture on photographs, both objects are notoriously difficult to spot visually. Sure enough, I could definitely make out the sharp edge of IC 434 slicing through the eyepiece's field, although the subtle protrusion of the Horsehead evaded detection. Nonetheless, I consider seeing IC 434 through a 6-inch instrument quite a triumph.

All the Details

To test the accuracy of the factory-installed NGC-microMAX digital setting circles, I followed their guidance toward the compact globular cluster M79 in Lepus, to the south of Orion. There it was, just slightly off-center in the field of my 22mm Panoptic. Switching to a 12mm Nagler eyepiece, I could partially resolve its myriad stars, another impressive feat for a 6-inch, since the brightest stars in M79 are close to 14th magnitude.

After spending some time admiring several southern open clusters in Puppis, I set the NGC-microMAX to M31, the Andromeda Galaxy, which was setting in the northwest at the time. By following the aiming advice displayed on the circle's digital readout, the target was within the field of the 25mm Plössl eyepiece that came with the NGT. M31's two companion galaxies, M32 and M110, were also in this same field of view, offering a pleasant panorama of the nearest major galaxy system to our Milky Way. Increasing magnification with the 12mm Nagler, I could also make out the major dust rift that encircles M31's outer girth.

A 6-inch f/5 reflector is usually thought of as a great wide-field telescope, but not necessarily compatible with planet-viewing. However, with Jupiter and Saturn both nestled among the stars of Taurus at the time, how could I resist? I plugged in my 7mm Pentax XL eyepiece once more and pointed the scope toward Jupiter.

I was pleasantly surprised. Jupiter showed an amazing amount of detail in its clouds, with subtle festoons and other irregularities clearly visible. Saturn was no less impressive; Cassini's Division was easily discernable around the rings. The Saturnian equatorial region was also evident. The sharpness of both planets pointed to the high quality of those Ukrainian mirrors.

The NGT's split-ring mount tracked the sky just fine throughout my tests, but I found it a little "bouncy" — most likely a result of the scant weight of the instrument. I often had to wait several seconds for the image to settle down when adjusting the focus, especially with higher magnifications. Tightening the axes helped a bit, but some unsteadiness remained.

I also found that the RCF-mini 1 focuser was a little stiff for my liking when turned by hand, especially with the 7mm Pentax. Its design makes tension adjustment impossible, although applying a slight amount of a dry silicon lubricant helped. The optional Motofocus eliminated the problem, but focuser travel was also somewhat limited. While this shouldn't prove to be much of a drawback with most eyepieces, those with a greater focus range may not work correctly. I ameliorated the problem by repositioning the truss rods into the second set of brass fittings on the nose assembly.

Overall, I give the NGT-6 very high marks in terms of optical quality and mechanical ingenuity. The mount moves very smoothly and tracks the sky effortlessly, while the optics are among the finest I have ever seen in a 6-inch telescope. If you are looking for a compact instrument capable of showing deep-sky objects as well as the planets, and want something a little more sophisticated than a Dobsonian, put the NGT-6 at the top of your list.

Phil Harrington's Star Ware, *a consumer's guide to astronomical equipment, is available through bookstores as well as directly from his website at: http://www.philharrington.net.*

Product Details

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Type: Newtonian reflector
Mount: Equatorial split-ring
Mirrors: 6-inch f/5 primary, 1.3" diagonal secondary
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Eyepiece height when aimed at zenith: 31" (without tripod)
Disassembled Size: Approximately 18" Height

STANDARD FEATURES:
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Split-Ring Equatorial mount with 9-volt DC clock drive

CELESTIAL PORTRAITS

Sagitta, Delphinus, and Vulpecula

This diminutive trio of autumn constellations packs plenty of deep-sky wonders.

by Tom Polakis

During the evening hours in early autumn, the sky continues to be dominated by the previous season's stars. Deneb, Vega, and Altair — the famed stars of the Summer Triangle — ride nearly overhead. This trio of stars and their respective constellations, Cygnus, Lyra, and Aquila, command the attention of any observer interested in the deep sky. Yet tucked along the margins of these striking constellations lie three small constellations that merit a closer look.

Sagitta the Arrow resides in the rich starfield between Altair and the popular double star Albireo in Cygnus. Although its star pattern measures scarcely 5° by 1°, it stands out nicely, appearing like its namesake. To the north, projected against the Great Rift of the Milky Way, lies the considerably more obscure form of Vulpecula the Fox. It contains just one 4th-magnitude star, Alpha (α) Vulpeculae, located a bit more than 3° south of Albireo. Moving south and east of Sagitta and away from the Milky Way's band, our gaze lands on the prominent constellation Delphinus the Dolphin. This tiny grouping dwells in the abrupt transition zone from the star-filled fields of the summer Milky Way to the sparsely populated autumn sky.

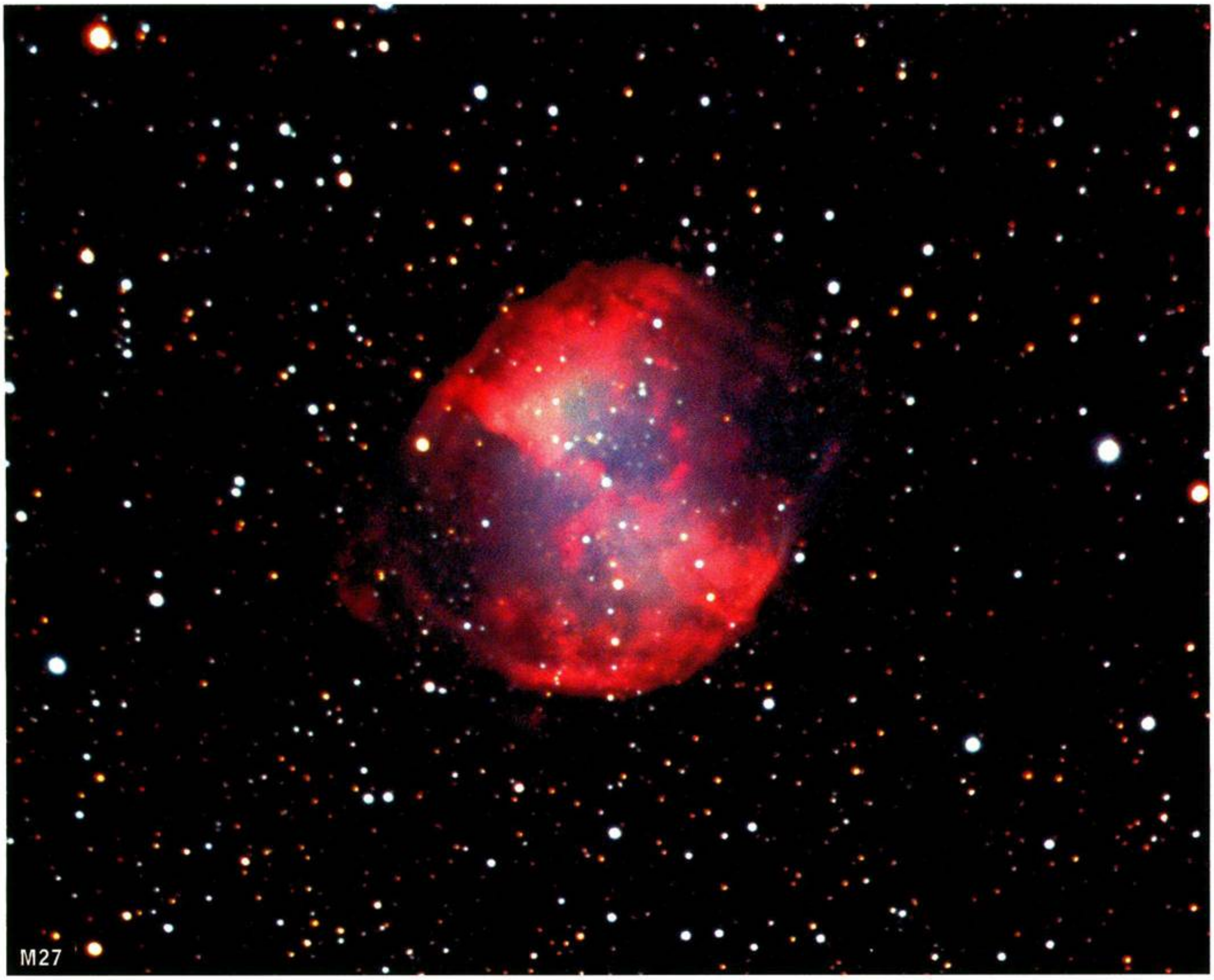
Our telescopic tour of the region begins in Vulpecula. Use binoculars or a finderscope and extend a line from Albireo through Alpha Vulpeculae to land upon the large asterism **Collinder 399**. This grouping also goes by the names Brocchi's Cluster and the Coathanger, the latter being obvious at first glance. Although cataloged as a cluster for many years, the stars of Collinder 399 are not related. Recent studies by the Hipparcos satellite confirm that the stars have different distances and proper motions. With a length of 1.5°, the object looks best at magnifications of 20x or less. Ten stars glow brighter than 7th magnitude, so the group appears distinct to the naked eye on dark nights.

The fine open cluster **NGC 6802** lies on the east end of the long string of Coathanger stars. In a low-power view, it's a bright, mostly unresolved haze measuring 5' by 2'. Upping the magnification in a medium-size scope reveals a dozen or so stars immersed in an associated glow. A 16-inch at 300x resolves the cluster into at least 30 stars, most of which glow at 13th magnitude or fainter. NGC 6802 lies about 30,000 light-years from Earth. Compare that with the foreground Coathanger stars, which are between 200 and 800 light-years from us.

Head 5° west of Alpha Sagittae to find the very challenging globular cluster **Palomar 10**. Although only 20,000 light-years away, it lies just 3° from the plane of the Milky Way, and obscuring material in the foreground greatly dims the stars. Its brightest members glow at 17th magnitude and barely resolve in a 20-inch telescope. The minimum aperture for spotting Palomar 10 is about 8 inches. Use medium magnification and look for a broadly concentrated halo some 2' across. View it at 300x to see if you can resolve the cluster's brightest stars.

Whether or not you succeed with Palomar 10, any telescope will show the pretty double star **Herschel 84**. Locate it 1° south-southwest of Beta (β) Sagittae. The 6th-magnitude

Artwork from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.



George Greaney

primary shows a distinct orange color. The bluish secondary lies half an arcminute to the northwest and appears 15 times fainter.

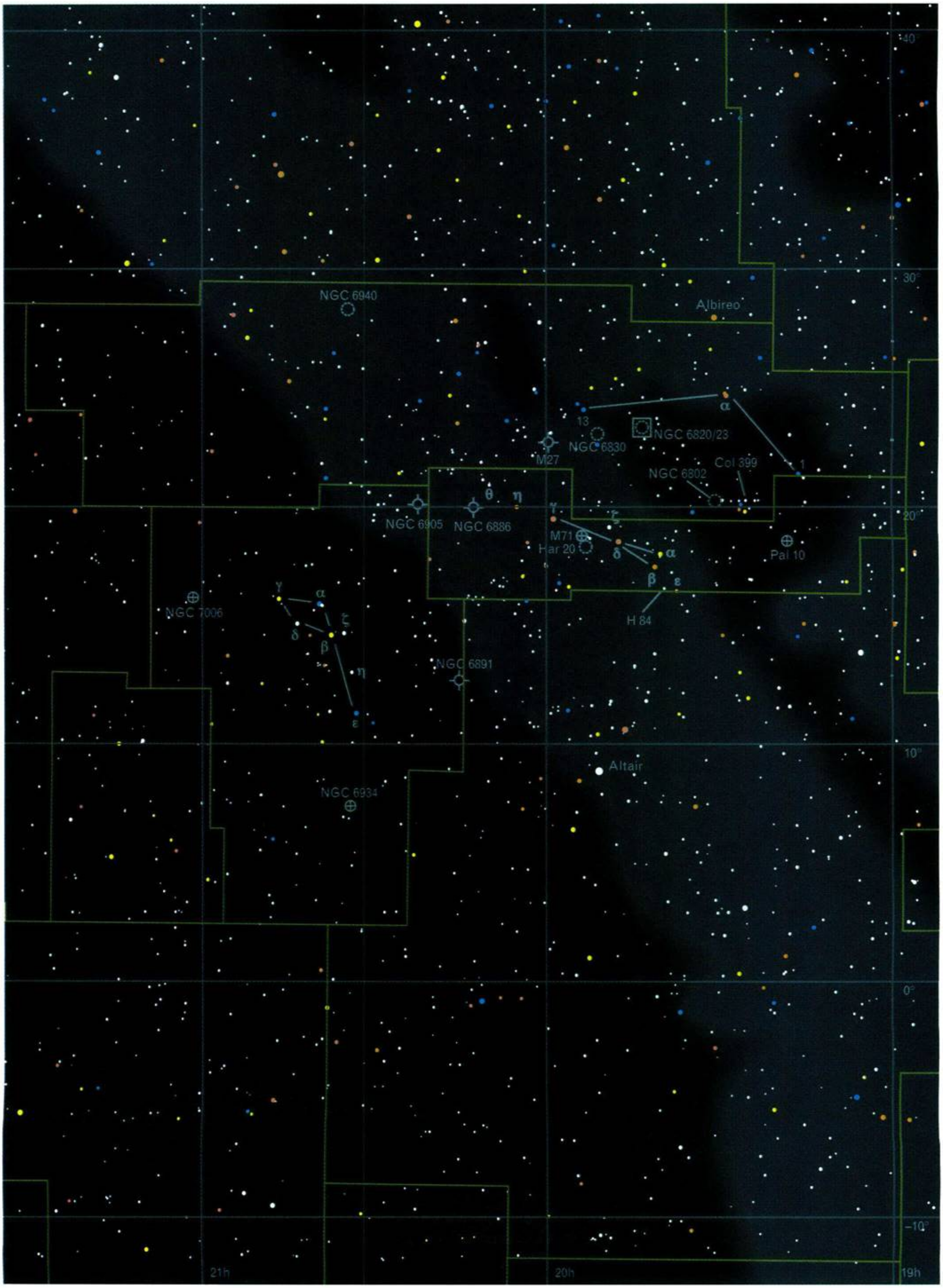
The loose globular cluster **M71** (NGC 6838) resides midway between Delta (δ) and Gamma (γ) Sagittae. Its relatively sparse nature (for a globular) led some early observers to catalog it as a dense open cluster. Its low density and relatively close distance of 13,000 light-years result in bright stars that can be resolved easily in small instruments. M71 holds more than 20 stars brighter than 13th magnitude, and a 6-inch telescope at 200x resolves the cluster against a hazy background 4' across. In a 12-inch, twice as many stars come into view. Most of the stars dwell inside an equilateral triangle 4' on a side, with the southern apex marked by a 10th-magnitude star. Some outlying stars bring the cluster's overall apparent size to 6'.

Now pan half a degree south from M71 to land on the loose open cluster **Harvard 20**. Twenty stars of magnitudes 12 and 13 scatter loosely across an area 6' across. Interspersed with the cluster are several 10th-magnitude stars. The edge of the cluster blends gradually with the rich fields of the surrounding Milky Way.

Vulpecula would be overlooked by many backyard observers were it not for M27 (NGC 6853), the **Dumbbell Nebula**. Seen from a distance of just 800 light-years, M27 ranks among the largest and brightest planetary nebulae in the sky. The Dumbbell owes its name to a double-lobe symmetry it shares with numerous other planetaries. Many observers liken its shape to an apple core. A small telescope shows only the two bright lobes. Several stars spread across the face, and the central star can be glimpsed at a high magnification. In a 10-inch scope, striations cross the inner regions and thin, fainter arcs appear at both ends of the lobes.

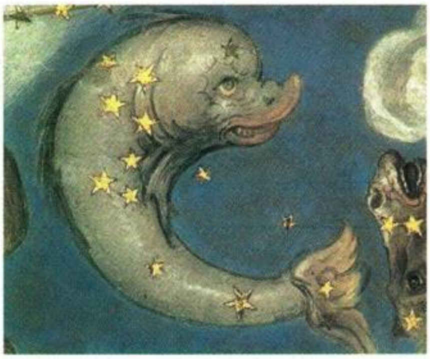
The Dumbbell looks impressive without a nebula filter, but such a filter provides a more detailed view. The thin arcs extend until they form a complete envelope around the inner nebula. Large Newtonians show a spectacular object laced with filaments and superposed stars in its interior. The dumbbell shape seen in small scopes begins to disappear into the almost spherical outer shell. Don't be shy about magnification — the nebula's high surface brightness allows new detail to be glimpsed with each upward step.

Two degrees west of M27 lies the nice open cluster **NGC 6830**, located 5,000 light-years from Earth. Forty stars between magnitudes 12 and 14 pack a 6'-diameter area. The cluster appears detached from the rich


40°
30°
NGC 6940
Albireo
13
α
NGC 6820/23
NGC 6830
M27
Col 399
1
NGC 6802
θ
η
γ
ζ
NGC 6905
NGC 6886
20°
M71
Har 20
δ
α
β
ε
Pal 10
H 84
NGC 7006
γ
α
ζ
δ
β
η
ε
NGC 6891
10°
Altair
NGC 6934
0°
−10°
21h
20h
19h

The Dolphin

"Parting day/ Dies like the dolphin, whom each pang imbues/ With a new colour as it gasps away/ The last still loveliest."
Childe Harold's Pilgrimage, *Lord Byron (1788–1824)*



Ancient mariners relied on the sky to tell them where they were. Perhaps that explains why so many watery constellations populate the celestial vault. The autumn sky alone boasts Aquarius the Water-Bearer, Capricornus the Sea-Goat, Pisces the Fish, and Cetus the Whale. And leading the parade as this celestial sea rises in the east: Delphinus the Dolphin.

The Greeks have two stories that tell how Delphinus attained stardom. In one, Poseidon, god of the sea, was looking for a wife. His first choice was Thetis, but a prophecy told that she would have a son more famous than his father. Poseidon quickly turned his attentions to Amphitrite. She wasn't keen on him, however, and sought refuge in the mountains. Poseidon sent a dolphin to change her mind, and when the animal's powers of persuasion worked, he rewarded it with a place in the sky.

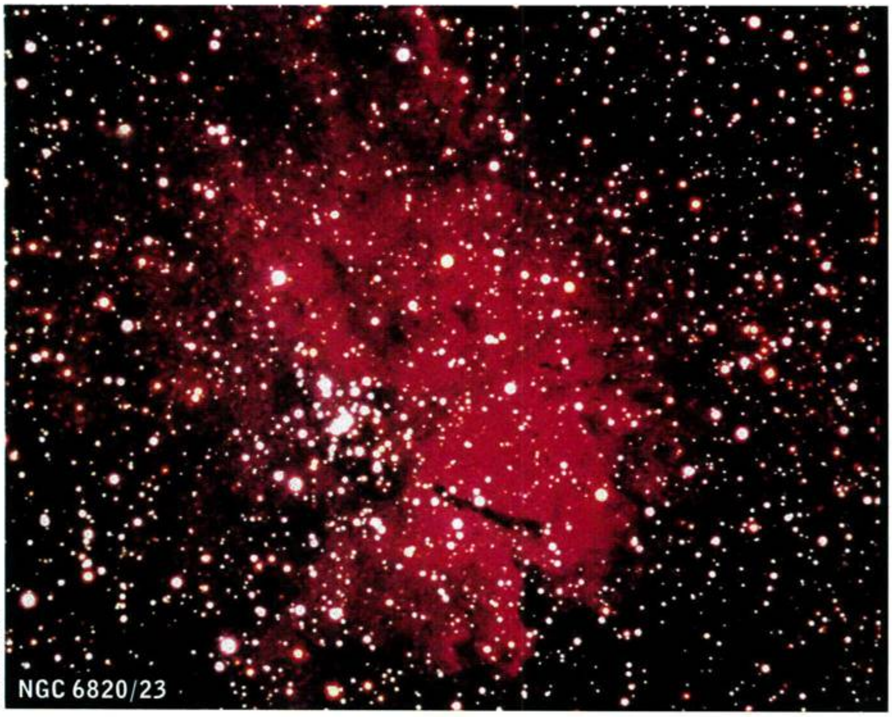
The second myth tells of Arion, a famous musician who was returning home to Corinth after winning a lucrative musical competition. More impressed with money than the fine arts, the sailors transporting Arion decided to kill him. They granted his last wish, however — to sing a song before leaping into the ocean. The song so moved Apollo, the god of music, that he sent a dolphin to rescue Arion. Arion rode the dolphin back to Corinth, the sailors were caught, and Apollo immortalized the dolphin.

Delphinus also commemorates something far more obscure than a life-saving dolphin. The constellation's two brightest stars are named Sualocin and Rotanev, which first appeared in the *Palermo Catalogue* of 1814. It was years before anyone read them backward and found they spelled Nicolaus Venator — an assistant to Giuseppe Piazzi at Palermo Observatory. — *Richard Talcott*

Deep-Sky Objects in Sagitta, Delphinus, and Vulpecula

Object	**R. A. (2000.0)**	**Dec.**	**Mag.**	**Size/Sep.**	**Type**	**Notes**
Palomar 10	19h18.2m	18°34'	13.2	3.5'	GC	
Collinder 399	19h25.4m	20°11'	3.6	60'	Asterism	Coathanger Cluster
NGC 6802	19h30.6m	20°16'	8.8	3.2'	OC	
Herschel 84	19h39.4m	16°35'	6.4/9.4	28"	Dbl	
NGC 6823	19h43.1m	23°18'	7.1	12'	OC	
NGC 6820	19h43.1m	23°17'	—	40' by 30'	BN	
NGC 6830	19h51.0m	23°04'	7.9	12'	OC	
Harvard 20	19h53.1m	18°20'	7.7	9'	OC	
M71 (NGC 6838)	19h53.8m	18°47'	8.0	7.2'	GC	
M27 (NGC 6853)	19h59.6m	22°43'	7.3	348"	PN	Dumbbell Nebula
NGC 6886	20h12.7m	19°59'	11.4	4"	PN	
NGC 6891	20h15.2m	12°42'	10.5	14"	PN	
NGC 6905	20h22.4m	20°07'	11.1	39"	PN	
NGC 6934	20h34.2m	7°24'	8.7	5.9'	GC	
NGC 6940	20h34.6m	28°18'	6.3	31'	OC	
Gamma Delphini	20h46.6m	16°07'	4.3/5.2	10"	Dbl	
NGC 7006	21h01.5m	16°11'	10.5	2.8'	GC	

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds.



NGC 6820/23

Michael Stecker

NGC 6934

Preston Scott Justis

surrounding fields, though defining the southern edge proves difficult. A parallelogram of 10th- and 11th-magnitude stars lies near the center.

Scan another 2° west to arrive at the young open cluster **NGC 6823** and its associated emission nebula, **NGC 6820**. When viewed in a 10-inch telescope, NGC 6823 shows a couple dozen 10th- to 13th-magnitude stars in an area 6' across. At the center of the cluster lies a tight group of newly formed stars. The Vulpecula Rift, a dark nebula 1,000 light-years away, dims stars in the region by up to two magnitudes.

Six times farther away than the rift, the emission nebula NGC 6820 spans 20' of sky, which translates to a physical size of about 40 light-years. A 10-inch scope won't show NGC 6820 without a nebula filter. A UHC filter reveals a milky haze that surrounds the cluster and extends to the east 10'.

Head from Vulpecula back into Sagitta to find the bright planetary **NGC 6886**. The tiny, 5"-diameter disk lies 2° east of Eta (η) Sagittae. Using a magnification of 500x, a 10-inch telescope shows a circular disk with a brighter center. The 18th-magnitude central star remains beyond the reach of backyard scopes.

A little more than 2° farther east, into the constellation Delphinus, lies the richly detailed planetary **NGC 6905**. An 8-inch telescope reveals a bright, spherical shell measuring 30" across with an enhancement on the eastern edge. The central star shows up steadily at high magnifications. In a 16-inch scope, the feature on the eastern side appears about 10" across and detached from the central star. More difficult to spot is a fainter enhancement extending west from the central star. The planetary's disk has a sharp edge that contrasts nicely with the surrounding sky. Both NGC 6905 and its neighbor, NGC 6886, lie about 6,000 light-years away.

The spectacular open cluster **NGC 6940** lies near the Cygnus-Vulpecula border. From our vantage point some 3,000 light-years away, even a modest telescope shows 100 11th- and 12th-magnitude stars packed into an area 20' across. Two empty areas on the eastern edge, both 2' across, contrast with the starry scene. Prominent star chains outline both regions, while a long dark nebula 2' wide snakes by the southeastern edge of the cluster.

NGC 6891 belongs to the class of "triple shell" planetary nebulae. Two recently ejected shells surround the central star, and these lie inside a more ancient, tenuous outer halo that's invisible in amateur telescopes. Small scopes show this bright planetary as a circular disk measuring 10" across with a sharply defined edge. Detail increases little in larger scopes, though the blue-green color and 12.4-magnitude central star appear more distinct.

The globular cluster **NGC 6934** lies 4° south of Epsilon (ε) Delphini. Seen across 55,000 light-years, its faint stars are difficult to see in a small telescope. Its 3'-diameter halo appears quite bright, however, and bears magnification well. At 250x in a 13-inch scope, NGC 6934 displays a granular appearance across its broadly concentrated core, but is barely resolved.

The attractive binary star **Gamma Delphini** marks the nose of the Dolphin. The two bright components now appear 10" apart, the widest separation they can show. They orbit one another with a period of 3,000 years, during which time the separation closes to as narrow as 0.8". Through a telescope at 100x, the yellow primary contrasts nicely with the bluish secondary.

Scan 3.5° east to our final object, **NGC 7006**. This globular cluster lies 135,000 light-years away, making its stars faint and beyond the reach of most backyard instruments. Even a 20-inch scope at medium magnification shows nothing more than a cometary haze less than 2' across. During nights of good seeing at magnifications above 300x, the brightest stars contribute to a granular look. **A**

Tom Polakis is an aerospace engineer living in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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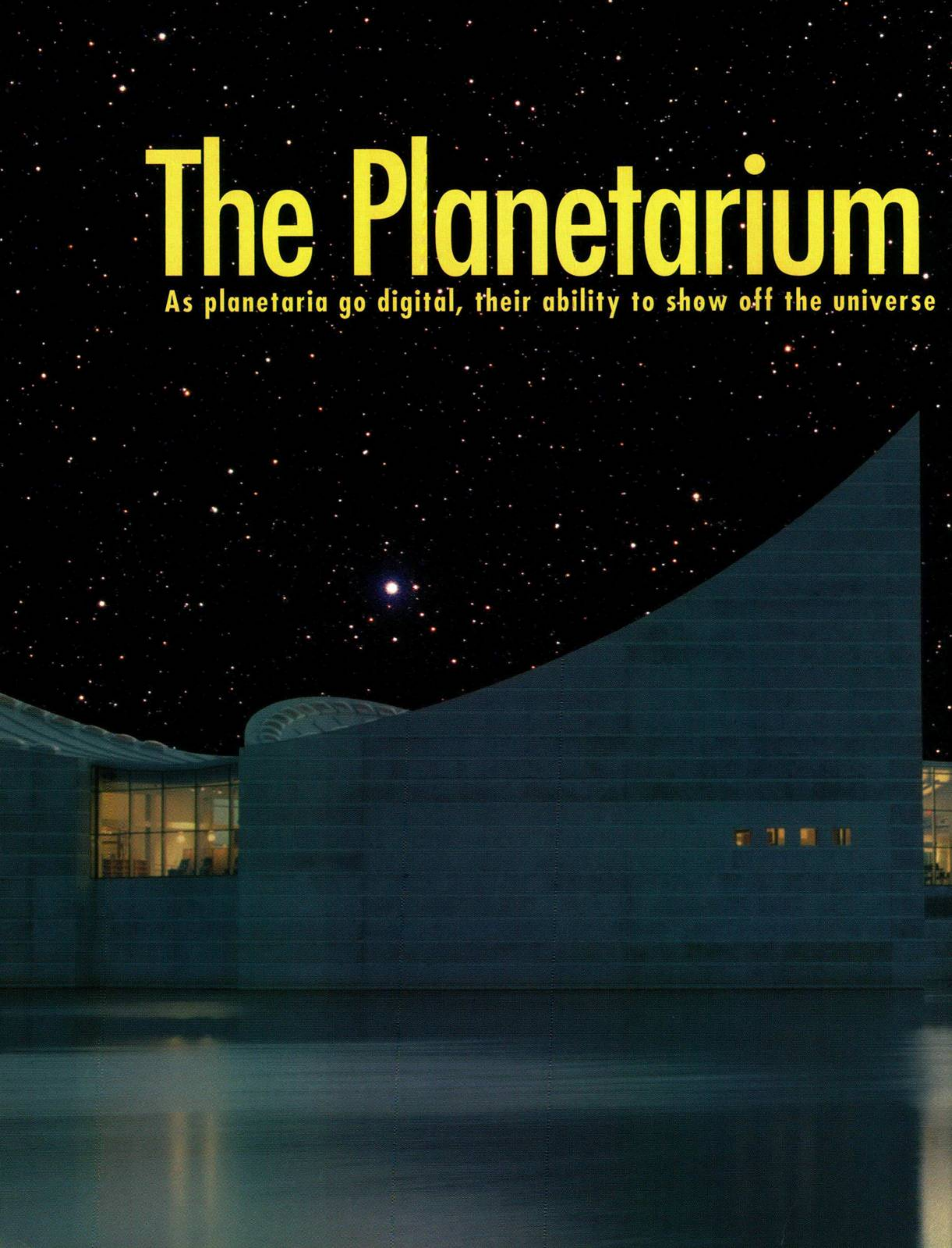
The Planetarium

As planetaria go digital, their ability to show off the universe

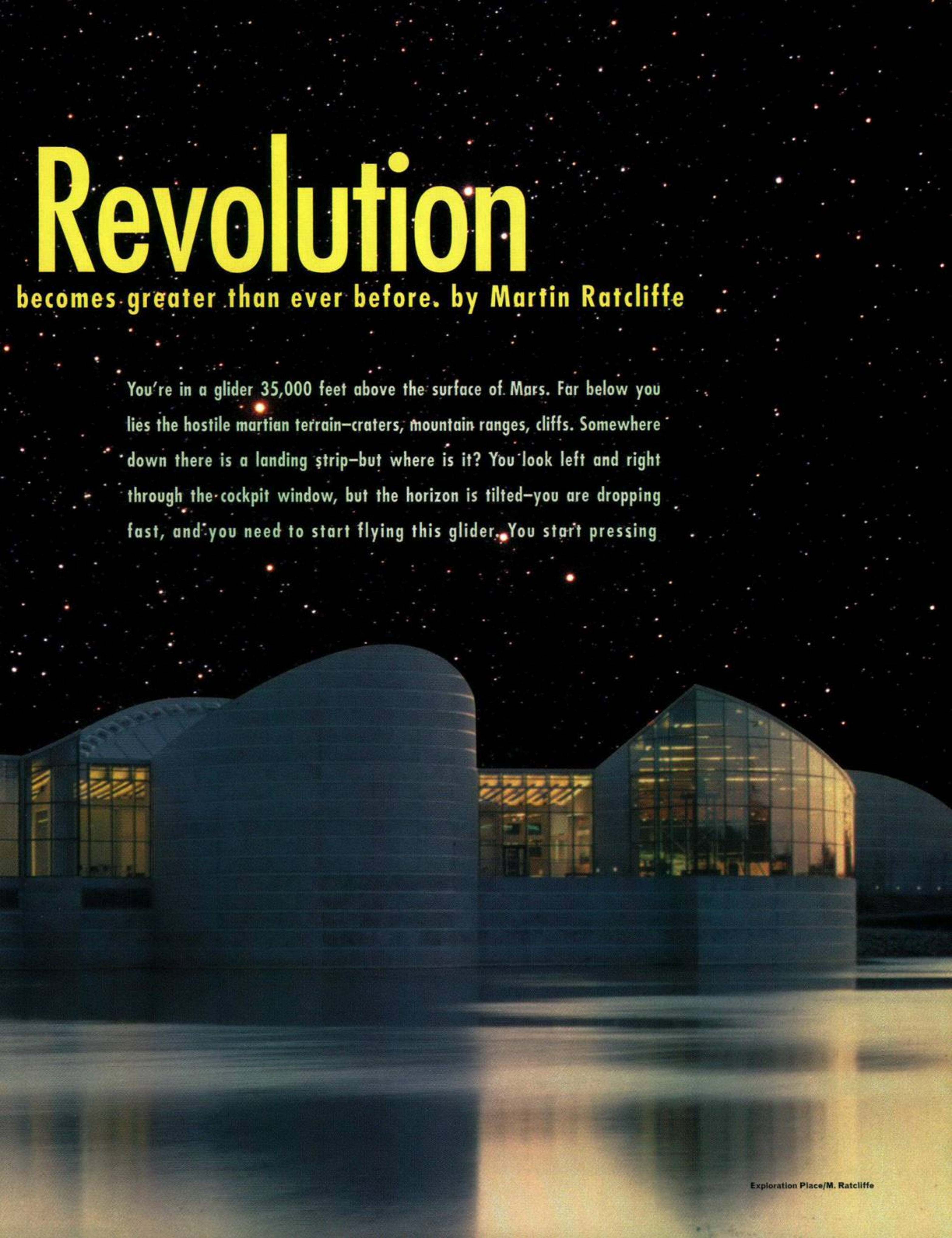


Revolution

becomes greater than ever before.

by Martin Ratcliffe

You're in a glider 35,000 feet above the surface of Mars. Far below you lies the hostile martian terrain—craters, mountain ranges, cliffs. Somewhere down there is a landing strip—but where is it? You look left and right through the cockpit window, but the horizon is tilted—you are dropping fast, and you need to start flying this glider. You start pressing



Exploration Place/M. Ratcliffe

keys on your digital flight controller–a five-button keypad–and sure enough, the glider responds immediately. You're coming in too steep–the ground is racing up to you. Pull up! Pull up!

"That's another crater in the martian landscape," informs the theater presenter. You and your 170 colleagues have just burrowed into the martian surface. But this is no computer game. Your "screen" is a 60-foot diameter dome that fills your entire field of vision. Each person controls the descent–it's a democratic vote, which is sampled 30 times per second.

Welcome to the planetarium of the 21st century. Gone are the days when planetariums had the technology to do little more than show slides of star fields on the surface of a dome. Today's planetarium has gone digital, bringing us a whole new way of viewing the universe.

"This is cool stuff," says one wide-eyed visitor of the Boeing CyberDome in Wichita, Kansas. The graphics are generated in real time, allowing high levels of interactivity with the audience.

New York's majestic Rose Center for Earth and Space at the American Museum of Natural History joined this new planetarium revolution on February 19, 2000, opening to massive publicity with its dramatic architecture and exciting new theater.

"We've had over a million people through the planetarium and over three million in the building since we opened," comments Dr. James Sweitzer, Director of Programs at the Rose Center, new home of the Hayden Planetarium.

The opening show at the Rose Center was what Sweitzer calls a "continuous-flow space show–a flight through real astronomical data sets." The emphasis is on using real data and images, not artist's conceptions. Flying straight up from Earth directly into space without edited breaks gives the audience a real connection to the universe. "From little kids on up –people get blown away by the enormity of (the universe) and really feel small–but in a good way," adds Sweitzer.

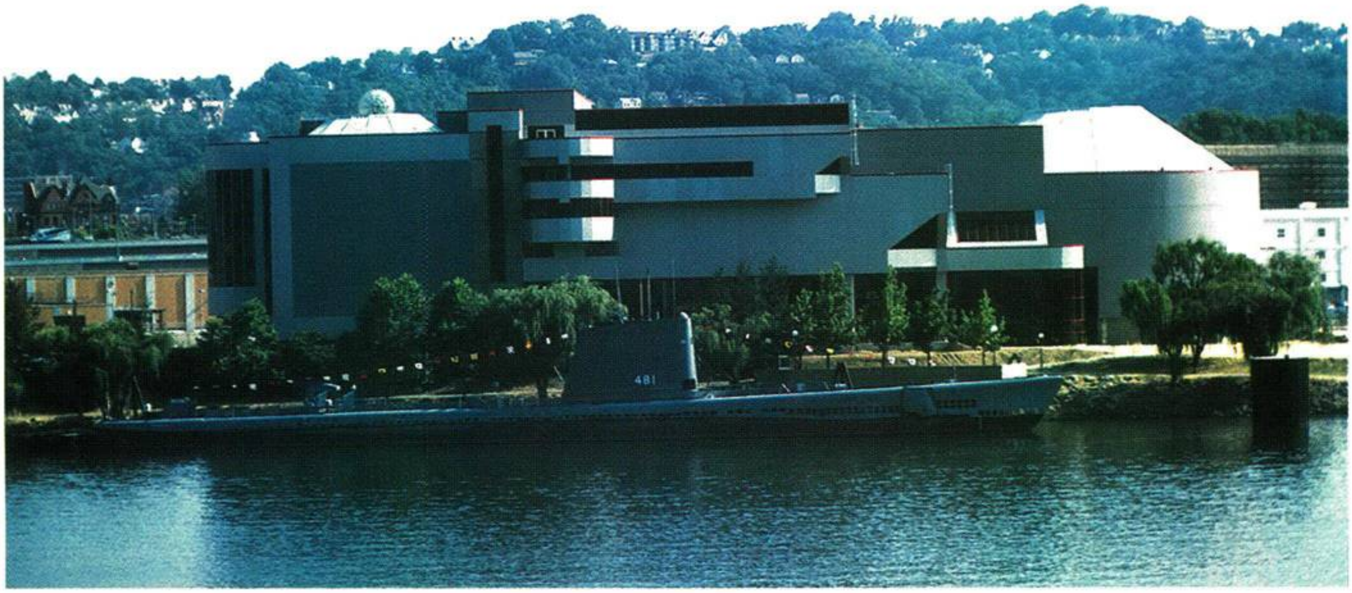
But do you really have to travel to New York City to be blown away? The answer is no. You can go to Chicago. Or Albuquerque, New Mexico. Or Wichita, Kansas. Or Lucerne, Switzerland. Even Baton Rouge, Louisiana, is getting in on the act. New theaters with full-dome digital video, rivaling an Imax movie in image quality, are popping up everywhere. A variety of new technology is being applied in different planetarium theaters, all with one aim in mind–to better tell the story of our amazing and beautiful universe with unparalleled visual clarity.

The Digital Age

So how do they do it? "All-dome video" is the new buzz phrase in the world of planetariums. Dazzling three-dimensional cosmic images, generated digitally in full color by large computer systems, are projected through a series of high-resolution

Since 1999, audiences in Chicago have been wowed by the beauty of the universe in Adler Planetarium's StarRider Theater.

Adler Planetarium



Pittsburgh's Buhl Planetarium boasts an interactive system that allows the audience to determine the fate of their simulated ride through space. Buhl Planetarium

video projectors to cover the inside of an entire hemispherical dome. Digital images from up to twelve separate video projectors are stitched together into a seamless 360° hemispherical image. These new planetariums are taking audiences into the depths of space as if they were on the journey themselves. It's the closest thing yet to Star Trek's holodeck.

"Everybody is looking for new ways to tell the stories on the dome, in ways we never could before, and the all-dome technology allows us to do this," says Steven Savage, owner and president of Sky-Skan, Inc. His company manufactures the new SkyVision all-dome system, along with many old-style, single special effect projectors.

The new digital video is generated in two ways–pre-recorded playback mode or real-time. The playback mode reaches high resolution but no interactivity. Productions using these techniques produce very rich, detailed scenes, such as a flight up to the International Space Station, or a trip through the pillars of the Eagle nebula with full hemispheric views.

In the alternative system, real-time images are "generated" by a computer as the audience sees them. With 30 frames per second, and typically six million picture elements (pixels) per frame, the process requires a huge image generator, equivalent of about seventy PCs running in parallel. Flight simulators use such systems, and only in the past three years have they found their way into the public arena. The advantage of these systems is that the audience can interact with scenes on the dome, transforming the planetarium into a space simulator where learning and exploration is placed in the hands of the visitor.

"This change from using classical to new tools represents a new way to get people back into science centers," adds Savage.

A Growing Audience

While many people still envision planetaria with old-fashioned star projectors and arrows pointing out constellations on the surface of a dome, this popular opinion is slowly changing, thanks to growing publicity. For example, David Letterman visited New York's Rose Center shortly after it opened, and then enthusiastically told the world all about it on his late-night talk show, drawing the audience into the splendor of the new planetarium experience. Sweitzer adds that such publicity helps bring knowledge of planetaria to a broader audience, stimulating "a whole new round of theater construction."

Since the first new digital all-dome video planetarium opened in 1999, more than twenty-five new or renovated facilities have opened, or will open, by the end of 2002. This planetarium revolution may affect every major planetarium in the world during the next decade. The new planetarium in Seville, Spain is perhaps most dramatic of all, as it has removed the star projector from the central pit entirely. Installed by the Nashua, New Hampshire-based industry leader, Sky-Skan, Inc., high-definition video projectors around the edge of the dome generate stars and 3-D digital video in the world's first "pitless" planetarium. Savage says, "All the stars are done in high definition video, so the best seats in the house are where they should be–in the center of the theater. Audiences always clap enthusiastically at the end of the show."

Old-Fashioned Star Shows

As far back as 1981, Evans and Sutherland, a Salt Lake City-based computer graphics company, began to set the stage for most planetaria by introducing the first digital star projector, Digistar. But the world's very first planetarium projector was invented in 1923 by Walter Bauersfeld at the Carl Zeiss Company in Germany. In 1935, the first Zeiss projector was installed at the Chicago World's Fair, now called the Adler Planetarium. Four more facilities followed prior to World War II–the Hayden Planetarium in New York, Fels Planetarium in Philadelphia, Griffith Observatory and Planetarium in Los Angeles, and the Buhl Planetarium in Pittsburgh.

Throughout the early space age, an explosion of theaters were built across the United States and around the world. All of them incorporated a central star projector that on occasion looked like a huge ant-like creature in the center of the domed room. Many visitors were as enthralled by the machine as much as by the night sky.

These star projectors incorporated a circular sphere with metal plates punctured by holes. A central lamp inside the sphere illuminated the holes, thus producing an elegant re-creation of the night sky on the dome high above the heads of the audience. Innovations in the 1970s brought slide projectors and elaborate single special effect projectors into the programs, plus pre-recorded shows that began to standardize the quality of productions.

Individual projectors for each special effect proved to be the biggest expense for theaters, as they needed one for meteors, one for eclipses, one for comets, one for aurora, and one to show the Big Bang. Many theaters had one hundred special effects projectors at a cost of thousands of dollars each. Once purchased, these projectors could do nothing else. A more economic solution was required, especially if smaller planetaria were to be able to show similar quality effects as the larger domes.

New Beginnings

It was the mid-1970s when television producer Terence Murtagh, who then was the Director of Armagh Planetarium in Northern Ireland, was experimenting with the new technology of video projectors inside the planetarium. The challenge was the geometry of the picture and how to prevent gray squares from spoiling the effect of images on the dome. "We were first to be able to modify projectors so as to achieve a geometrically correct image on the dome, and the first to electronically prepare and mask images so that when projected, they looked as though they were floating in space," says Murtagh.

During the mid-1980s, Murtagh also began experimenting with a three-button interactive system that linked the audience directly to a bank of laser disk players. The audience went on a self-guided tour of the solar system with a live presenter who played the role of the ship's guide. This first electronically interactive planetarium show opened to rave reviews, where the audience, not the producer of the show, directed the sequences. This technology planted the seeds for the current revolution in planetaria. "We wanted to cover the whole dome in one single moving video image," remembers Murtagh.

But as Murtagh explains, the driving force was not the technology, but what producers wanted to do with their audience. "I thought that the visual experience of placing an audience inside the rings of Saturn would be spectacular," remembers Murtagh. "What technology did I need to do that effect?" The emphasis was backwards to the old planetarium premise –visual experience first, and the hardware second.

Further Advances

By the late 1980s, the ideas from Armagh hopped across the Atlantic, and the new Christa McAuliffe Planetarium in Concord, New Hampshire, became the first U.S.-based interactive planetarium. This interactive planetarium reflected a new level of involvement of the audience in the learning process.

The second facility to include an interactive system was at the new Henry Buhl Jr. Planetarium, part of the Carnegie Science Center in Pittsburgh, Pennsylvania, built to replace the magnificent but aging original planetarium. It was four years later when the vision of flying through space in full color was realized, by virtue of new technology introduced by Evans and Sutherland called StarRider. Murtagh calls it "the third major technological breakthrough in planetarium projection, since the optical projector from Zeiss in the 1920s and the original all-electronic Digistar from Evans and Sutherland in the 1980s."

Savage, who ran the company that prided itself in both supplying video

The Fight to Save the Night

How often have you stepped outside on a clear night, hoping to see a veil of stars sparkling overhead, only to find that the Milky Way appears faint and washed out, or sometimes even nearly invisible? Thanks to the increasing problem of light pollution, amateur astronomers all over the world are being forced to remote locations to find skies dark enough for good observing.

Over the past three decades, the problem has slowly worsened, to the point where the view of the sky is altered in some degree for nearly 90 percent of Americans. While we should be able to easily see at least 2,600 stars on a clear, moonless night, people in many urban areas, and an increasing number of suburban and even rural areas, can now view less than 100 stars on a given night.

What causes light pollution? When too much artificial light enters the night sky, it reflects off of airborne water droplets and dust particles, causing skyglow. Poorly shielded and improperly installed lighting fixtures that needlessly send light careening outwards are the main culprit of the problem. It has been estimated that America wastes about $1.5 billion per year on electricity.

And not only does light pollution affect sky-gazers, it can also be intrusive and even dangerous, when light shines from one property onto another, or into a driver's eyes on the road.

But in recent years, measures have been taken to tackle this problem. Since 1988, the International Dark Sky Association (IDA) has been working to educate the public on light pollution, showing its adverse affects and demonstrating ways to correct it. This non-profit organization currently boasts more than 7,000 members.

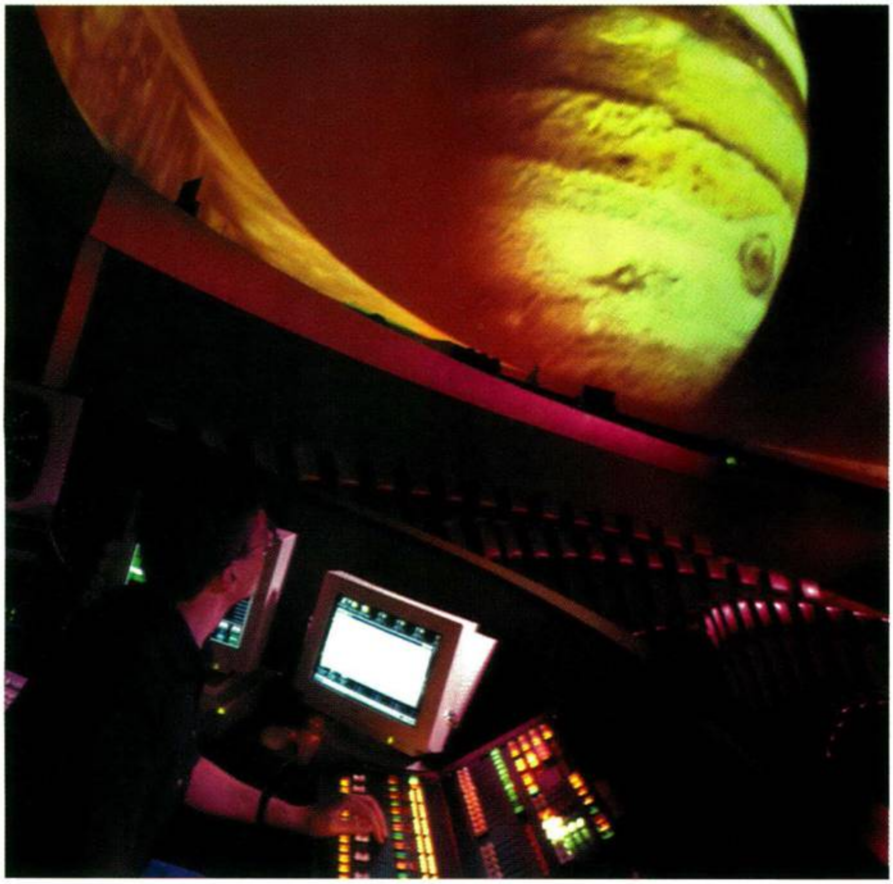
Now planetaria are getting in on the act with a new mini-show designed to be added to the beginning or end of any star show. Produced by the Southeastern Planetarium Association (SEPA), *Saving the Night* strives to make the public aware of the issue and promote the usage of proper lighting techniques. Written and narrated by astronomer/author David Levy, the show is approximately 11 minutes long and features 29 original pieces of artwork.

For more information on how you can join the effort to put an end to light pollution, check out the IDA website at www.darksky.org. *—Elesa Janke* solutions to the planetarium community as well as the traditional single special effects projectors, recognized that he had better start developing a new system himself or get out of the business. "I thought the demo (of StarRider) was so unbelievably cool that it inspired me to do Sky Vision, which first showed at the July 1998 International Planetarium Society conference in London, England. It was demonstrated alongside StarRider–just two years after StarRider's first launch in Pittsburgh. This was the first time anyone saw SkyVision. Everyone who sees it reacts positively to it."

Leaders of the Pack

Currently, two facilities are leading the way in interactive shows. Adler Planetarium in Chicago and the Boeing CyberDome at Exploration Place in Wichita, Kansas boast the world's first interactive StarRider theaters. Adler opened in 1999 and the CyberDome followed in mid-2000. "Crack the Cosmic Code," a new interactive experience in the CyberDome, enables visitors to use a five-button keypad on their armrests to navigate inside the Crab Nebula and discover for themselves what mysterious object is emitting rapid pulses. Audiences select one of five astronomical objects and point the Hubble Space Telescope toward it to acquire a spectrum. They have to determine if the objects are moving, rotating or expanding.

In another interactive example, three stars rock back and forth due to the motion of the earth. Based on the effect of parallax, the audience tries to determine the relative order of distance of the three stars. The interactive system allows the audience to do experiments with full color graphics in a way that was impossible five years ago. But astronomy is not the only subject open to a domed environment. Savage comments that "more people who see it realize this environment can be used to explore other sciences, and that is happening actively." Murtagh agrees. "There's the liberation of the planetarium from being a screen with stars to being an immersive environment beneath which puts people not only in amazing places in space, but inside their body, beneath the ocean, or wherever we choose."



Years ago, a typical planetarium production staff included artists and photographers. Today, computer graphics programmers have taken over the magic. Adler Planetarium

A Bright Future

The revolution won't directly affect the excellent work smaller facilities already do, but they may benefit as a spin-off by getting access to expensive computer graphics far more cheaply than if they were originating the material. And the big cities are not the only ones taking the lead. The $62-million Exploration Place in Wichita, Kansas proves that smaller towns can, given the vision of the community, come together to give dramatic new theaters a chance to generate a new magic in this digital age.

And because astronomy is the most popular science among the general public, (who doesn't harbor some curiosity about black holes?), the number of planetaria continues to grow. Worldwide, over 92 million people attend planetarium shows each year.

Murtagh is thrilled by what is happening. "There will soon be the ability to show the real world in this environment," he says. "Imagine being surrounded by a real-time image of elephants at the water hole in Africa, or under the ocean near gushing smokers. Real-time information and visuals will transform the domed screen of the planetarium into an immersive adventure world where astronomy will never be forgotten, but where art, science, and nature will be presented in a format as new and exciting as was the arrival of the first moving pictures. For certain, you ain't seen nothing yet!" ◼

Martin Ratcliffe is president of the International Planetarium Society, Director of the Boeing CyberDome Theater, and Astronomy's *monthly Sky Show columnist.*

ask Astro

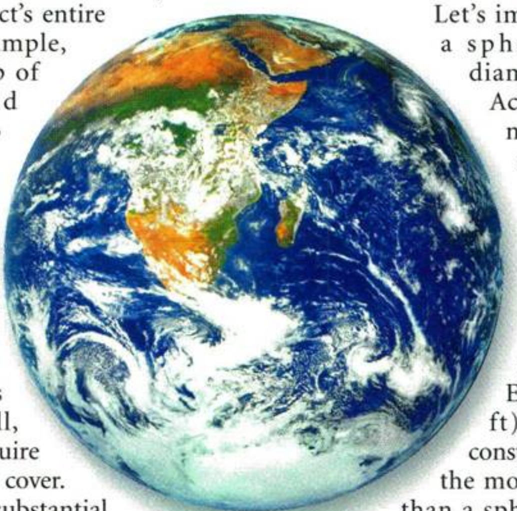
Space in the Round, Ice Blue and Red Hot, Where am I?

Why are so many objects in space round? — *Tom Choal, Roswell, New Mexico*

Spheres are nice, tidy geometric shapes that possess the smallest possible surface area for a given volume. You can easily prove this fact by painting an object's entire surface. For example, consider a lump of clay: You could pattycake it into an enormous thin sheet, which would require a lot of paint to cover both sides. Or you could roll the same lump between your palms into a small ball, which would require very little paint to cover.

Objects with substantial mass, such as stars, planets, and even the larger moons, have sufficient self-gravity to "pull themselves" into spheres, where no part of their surfaces are farther from the center than any other. (Fast spinning objects, however, may possess an equatorial bulge, since material at the equator spins faster than at the poles.)

It turns out that only bodies with too little mass to have much self-gravity, such as asteroids and small moons, can remain irregularly shaped. — *Bob Berman,* Astronomy *columnist and author of several astronomy books, including* Cosmic Adventure: Other Secrets Beyond the Night Sky *(Quill)*



Earth's rapid rotation rate takes our globe slightly out of round. SPL/Photo Researchers/NASA

If Earth were the size of the period at the end of this sentence, how large would our solar system, galaxy, and universe be in comparison? — *Jason Green, Cornwall, England*

Let's imagine Earth as a spheroid with a diameter of 1 mm. According to our new miniature scale, the sun, now roughly the size of a regulation American softball, 11 cm (4.3 in), lies a mere stone's throw from Earth at 12 m (39 ft) away. Earth's constant companion, the moon, is no larger than a spherical speck of dust with a diameter of 0.3 mm (0.01 in), and circles Earth from a distance of only 3 cm (1.2 in).

Moving outward, keeping the sun as the center of our coordinate system, we find eight planets ranging in size from the smallest, Pluto, with a diameter of 0.18 mm (0.007 in), to the grand pill-sized, Jupiter at 1.1 cm (0.43 in). The interior planets, Mercury, Venus, Earth, and Mars, all lie within 18 m (59 ft) of the sun. Giant Jupiter lies a bit further at 62 m (203 ft), while Pluto's eccentric orbit hurls the planet as far as 450 m (1500 ft) — slightly more than the length of the flight deck on a modern U.S. aircraft carrier — from the sun.

Past the planetary domain of the solar system, we move into the realm of the comets. The Kuiper Belt, a reservoir for short-period comets, extends from the orbit of Neptune, 360 m (1200 ft), to as far as 6 km (3.7 mi) away. An even larger spherical distribution of long-period comets reside in the Oort Cloud with a radius of roughly 1,200 km (746 mi), the approximate driving distance from Atlanta to Key West.

The nearest star to the sun is Proxima Centauri, about 3100 km (1900 mi) away or the distance from Chicago to Los Angeles. And on our new scale, the Milky Way Galaxy is a disk about 97 million km (60 million mi) in diameter, about eight thousand times the diameter of Earth. Our new pint-size Earth is situated about ⅓ of the way from the center of the Milky Way, some 24 million km (15 million mi) or about 60 times the present separation between Earth and the moon.

The Milky Way's nearest neighbors, the Magellanic Clouds, are sister swarms of stars 12 million km (7.5 million mi) in diameter, hovering about 120 million km (75 million mi) away. And the Milky Way's neighbor spiral, the Andromeda Galaxy (M31), looms as large as a 144 million km-(89.4 million mi)-diameter pancake 1.7 billion km (1 billion mi) away.

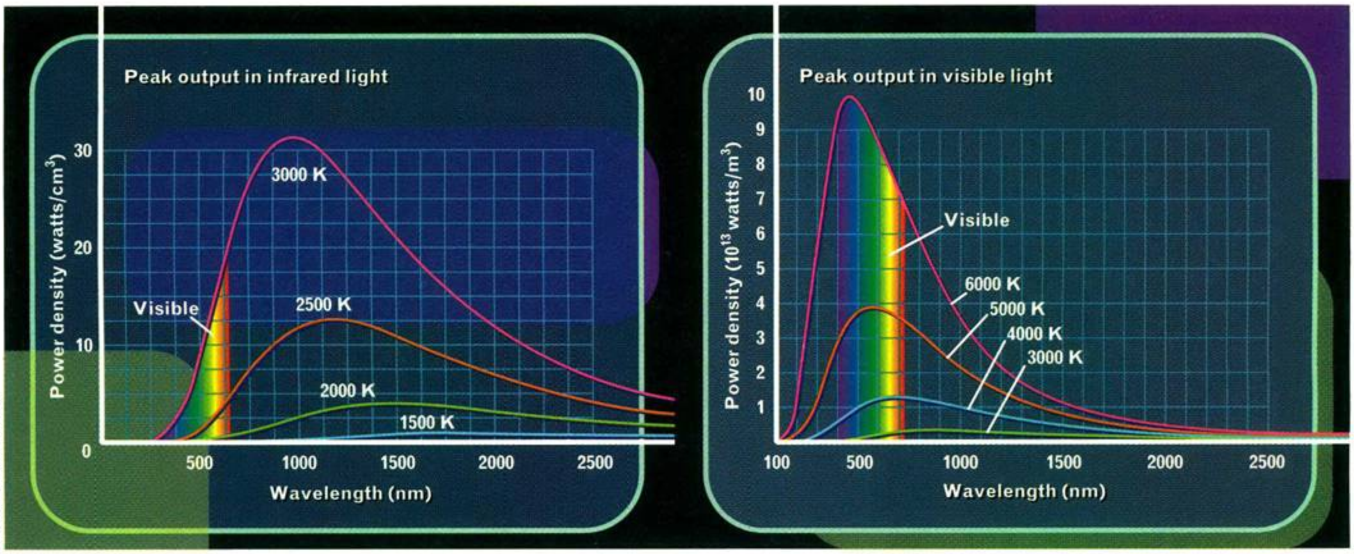
Finally, the observable universe, with a radius roughly 13 billion light-years by our standard scale, would still be an imposing 9 trillion km (6 trillion mi) in radius. No matter how you slice it, Earth occupies a mere nano-fraction of a universe that looms large on every scale of space and time. — *William Schomaker, associate editor*

Why are hot stars bluer than cool stars? — *Kirsten Sterby, Brampton, Ontario, Canada*

In our daily lives, red usually symbolizes hot, as in "red hot," while blue — the color of the ocean and of ice — indicates cold. In truth, the relation between color and temperature is just the opposite.

Heating a poker in an intense fire, you'll see that it glows red as it's heated to a couple thousand degrees. But if you could heat it much more, it would take on a slightly bluish tint.

Light, including that emitted from *the hot poker, is a wave-like flow of* energy. Of the light we can see with our eyes, red has the longest (lowest



Warm stars (right), like the sun, emit most of their energy as visible light. For cooler stars (left), low-energy, infrared radiation dominates.

Astronomy: Rick Johnson

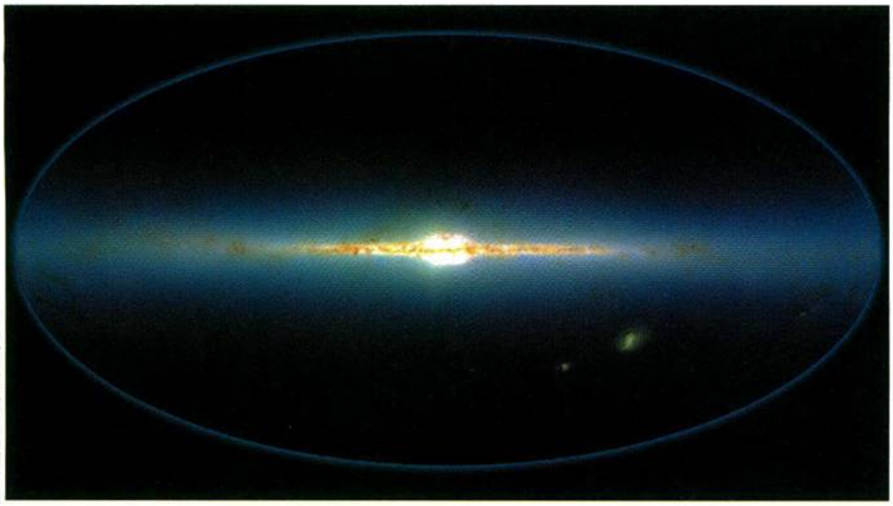
energy) waves. Violet has the shortest (highest energy) waves. On the long-wave side of red we find infrared, followed by lowest energy radio. And on the short-wave side of violet we find ultraviolet, followed by x rays and ultra-energetic gamma rays.

Temperature is really just a measure of the inherent energy within an object. A very low-temperature body can produce only radio or infrared radiation and does not glow to the eye. Very hot objects, with lots of energy, can produce radiation all the way from radio waves to x rays.

The color that your eye perceives depends on the mixture of the wavelengths in the radiation. A 2,500 Kelvin (4,000° F) star is just hot enough to glow red to the eye. Heat the same star to solar temperature (6,000 Kelvin, 10,000° F) and it will first turn orange, then yellow-white. Above 20,000 Kelvin the star will appear blue-white.

Star colors are really quite subtle and hard to detect, although the cooler, reddish ones will stand out easily for you. Amaze your friends by saying "look, a cool star." — *Jim Kaler, Astronomy Department, University of Illinois. Visit the "Star of the Week" on his website at http://www.astro.uiuc.edu/~kaler/sow/sow.html.*

More than a day trip: It's a long drive to the center of the Milky Way Galaxy.



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How are we certain of our location within the galaxy? — *Don Fraser, Red Deer, Alberta, Canada*

Our knowledge of the sun's location in the Milky Way Galaxy is based on a rich and interesting 200-year history of stellar position measurements. Throughout this bicentennial era, results have been mixed, but astronomers today are pretty confident that the sun lies about 25,000 light-years from the galactic center — about ⅕ of the distance from center to edge.

When astronomers look at the night sky, they see considerable brightness variation among the dimmest and brightest stars. Early location estimates did not account for the fact that interstellar dust makes stars appear fainter, or that stars do not have the same intrinsic brightness. As a result, until about 1920 most astronomers thought the sun was located at the center of our galaxy. Astronomer Harlow Shapley demonstrated the error in this assumption by measuring the distribution of globular clusters, which he more or less correctly assumed were clustered about the distant center of the galaxy.

Today, we know where the sun is located with relative certainty by using the same tried-and-true star count methods, but also by better understanding the intrinsic brightnesses of stars, and a more sophisticated treatment of light absorption caused by interstellar dust. — *Chris Conselice, Space Telescope Science Institute* ■

CONTACT INFO

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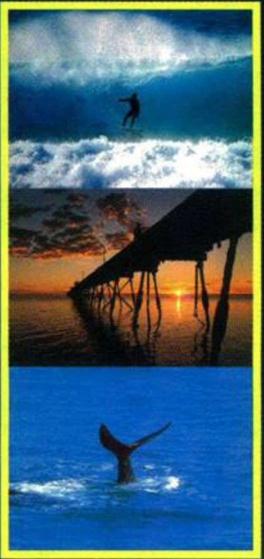

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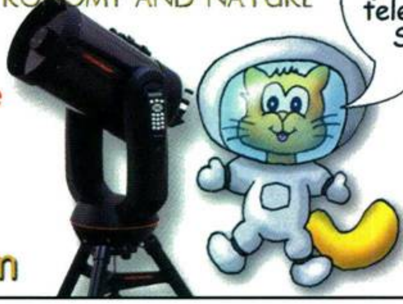
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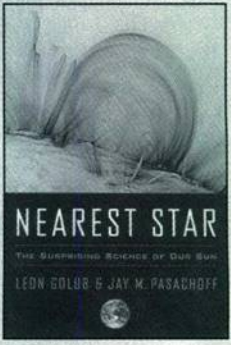
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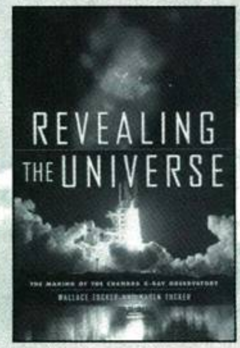
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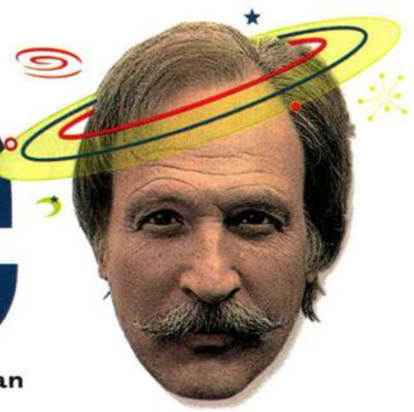

by Bob Berman

Astronomically Challenged

The TV series "Survivor" illustrates what we already know: Ours is a competitive society. Astronomers, of course, are not exempt. Watch what happens when we gather to show off our newest equipment. Admiration sometimes ripens — especially with guys — into an emulous need to keep up with the Kecks. Maybe I'm wrong. Perhaps times have changed and today's evolved male no longer tosses his socks on the floor at night, knows his car's horsepower, or is obsessed with having the biggest telescope for reasons a psychologist would have no trouble explaining.

Few star parties end in barroom brawling because the starry heavens offer civilized ways to channel our competitive urges, and often we're perfectly happy just to challenge ourselves. The most famous such contest is the Messier Marathon. For backyard astronomers, this trial has long been the gold standard: To observe all nine dozen of Charles Messier's deep-space objects in a single night. It's difficult any time of year, but it's impossible in the fall when scores of faint Virgo galaxies hide behind the sun. This leaves alpha males with a strange autumn restlessness.

To prevent this unchannelled aggression from erupting into bizarre unproductive activities like road rage or watching old Charlton Heston films, the solution is clear: New celestial competitions. Hence the following seven, which I call the Hubble Challenge, the Green Dash, the Birthday Blitz, the Million Light-year Marathon, the Terminator Trial, the No-Numbers Galaxy Chase, and the Battle of the Star-Splitters. See if any of these contests get your juices flowing.

The Hubble Challenge: In a single hour, how many celestial objects can you observe that emitted their light since the Space Telescope was launched? If performed this fall, that means everything closer to Earth than 11½ light-years, since Hubble went into orbit in April 1990.

The inventory includes about a dozen moons detectable with amateur equipment, plus eight planets, several asteroids and some 16 stars (a few of which are binary and can count as two) and any stray comets — for a grand potential total of more than three dozen objects. One third of these can be seen with just the naked eye this month, including Sirius, Epsilon Eridani, 61 Cygni and Procyon.

The Green Dash: In one hour, how many green targets can you find? If this were formalized, a judge could verify each emerald object. (Just as chess players have employed unfair tactics — the former World Champion Nimzovich advised setting up the board so that the glare goes into an opponent's eyes — one might "accidentally" turn on a bright red night vision light as the judges approach, producing a green afterimage just as they peek through the eyepiece). Green sky stuff includes the planet Uranus, the Orion Nebula, planetary nebulae such as NGC 6543 in Draco, and many others. Here, aperture is king; larger scopes would definitely do better.

The Birthday Blitz: Given one hour, how many objects can you see and identify whose light began its journey after you were born? The potential winner might be the oldest contestant who still somehow had some eyesight remaining. A 90-year-old could look for everything nearer than 90 light-years, of which there are thousands. To make the contest less open-ended, there might be categories, such as The Under-30 Challenge. As a wonderful around-the-campfire activity, it could be limited to naked-eye objects.

The Million Light-year Marathon: The winner is the observer with the most points, earned according to the distances of the objects observed. A galaxy two million light-years away (e.g. Andromeda) yields just two points, while the bright M81/M82 duo near the Big Dipper earn 10 apiece. Observe and identify two dozen bright Virgo Cluster galaxies like M87 and you've grabbed more than 1,000 points. The most distant realms are faint and challenging, but the 13th magnitude galaxy NGC 4889 in the far-off Coma Cluster would be worth 400 points alone. A few oddballs can give a contestant a quick boost. The 13th-magnitude quasar 3C 273 in the heart of Virgo just above the star Porrima, probably the most distant object observable with a 10-inch scope, lies some two billion light-years away and could rack up 2,000 points!

Variation: A one-hour time limit.

Another Variation: The Earthlight Marathon. You must gain 5,000 points by identifying objects with combined distances of five billion light-years, surpassing the expanse that Earth's image has now traveled across the universe.

The Terminator Trial: This challenge exploits the slow creep of sunlight across the moon's surface. Though it moves just one percent as fast as morning rushes along Earth's equator, the moon is so small that its large curvature per mile lets new features materialize continuously as the sun pops over its horizon. This is particularly dramatic when the moon is near first quarter and the terminator chugs along at its greatest angular speed because it is then moving at right angles to you.

One example: A day after first quarter the raised walls of Eratosthenes strikingly catch the rising sun at the terminator, but that sunken crater's floor and central mountain still lurk in darkness. In a four-hour observing session, the day/night line shifts by very nearly this crater's 37-mile diameter. This allows the sun to abruptly strike its mountaintop, which suddenly materializes as a brilliant pinpoint against the inkiness of the crater's still unilluminated floor. The contest: Which telescope sees it first?

Battle of the Star Splitters: Among several scopes, what's the closest double star that can be split on a given night? This has wonderful potential for mine-is-better-than-yours behavior, one of the tacit goals of competitive sport. Larger refractors with their unobstructed light paths should really shine in this arena. But can they overcome the brute force of 8-inch and larger reflectors and Schmidts?

No-Numbers Galaxy Chase: This final challenge acknowledges that ours is an era of setting circles and computer guidance, and that relatively few observers truly know the sky. Buttons are pushed, the telescope slews, the object appears. While nothing is wrong with this, there ought to be a special category for those who master the heavens and find faint nebulae simply by pointing their instruments at a familiar piece of celestial real estate.

This contest's winner is the one who finds and identifies the most deep-space objects using no computers or setting circles. Only telescope, finder scope, and Telrads are permitted. The backyard observer is strictly on his/her own, armed with instrument, sky, and memory alone.

One variation: Binoculars only.

I think we'd all enjoy hearing from individuals or groups who take up these challenges or who suggest other tournaments beyond plain-vanilla hunts for Messier or NGC objects.

Finally, to determine the Ultimate Galactic Victor, the winner of each of these contests is sent into the forest with just a spear and image-stabilized binoculars. The survivor who emerges receives a subscription to *Astronomy* and *Modern Warrior*, a year's supply of NASA photos, and fresh meat. ■

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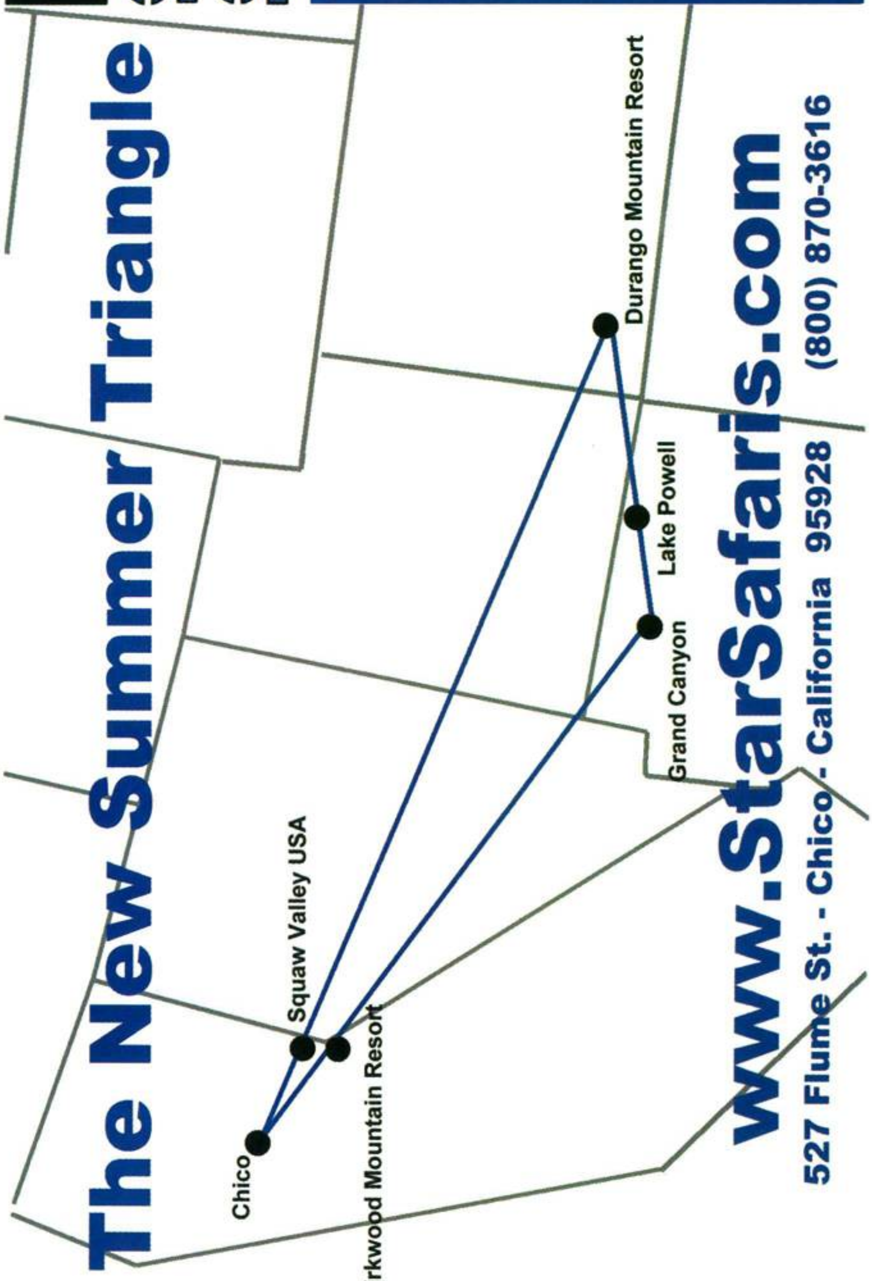

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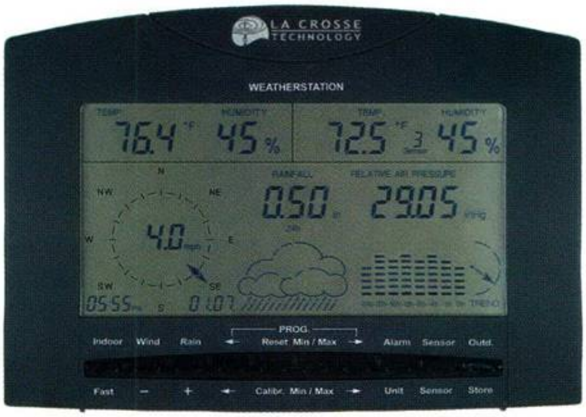

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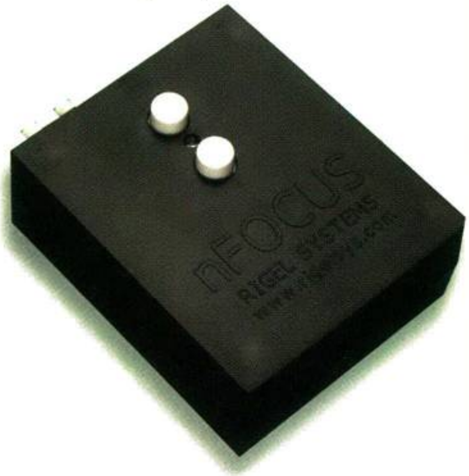

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Compatible with JMI, Celestron, Meade, Van Slyke Engineering and other focus motors, the nFOCUS is available for $39.95, plus $4.95 shipping. (California residents must add 8% sales tax.) Contact Rigel Systems, 26850 Basswood Avenue, Rancho Palos Verdes, California 90275; phone and fax, (310) 375-4149; website, www.rigelsys.com.

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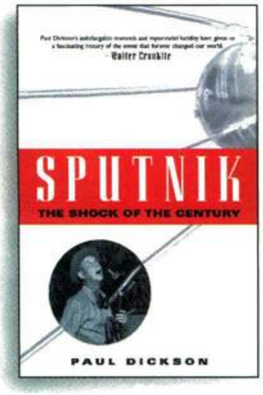


SPUTNIK: The Shock of the Century

Paul Dickson, 320 pages, Walker & Company, New York, 2001; ISBN 0-8027-1354-3; hardcover, $27.

▶ How ironic that Earth's first artificial satellite launched a sea change in technology, politics, and society. Like the *Challenger* explosion or the Oklahoma City bombing, most people remember exactly when and where they heard the news about Sputnik. Dickson's book chronicles the Sputnik event as well as its global effects.

SPUTNIK takes a close look at why Sputnik shocked America and heightened the Cold War. Public fear grew as Americans began to think they were taking a backseat to the U.S.S.R. It sent America's complacent 1950s mindset into a tailspin. Industries, scientists, and the military mobilized to counteract and overcome the perceived Soviet space advantage.

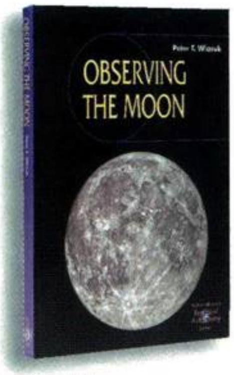
Dickson explores the reasons behind the Russian satellite public relations coup and how and why Eisenhower used Sputnik to champion his argument for a satellite spy system by emphasizing the "freedom of space" principle.

Readers learn about behind-the-scenes infighting among politicians, researchers, and military advisors. This book offers a fascinating look at the myriad changes Sputnik brought to everyday life since its launch on October 4, 1957.

In a short but refreshing change of pace, one chapter highlights the negative ramifications caused by Sputnik's launch. Some educators lament the dependence upon computer software for science, engineering and math.

Critics argue that this teaching shift from hands-on experience to more theory and abstract thinking underscores the engineering failures that resulted in Hubble Space Telescope's flawed original mirror, the leak at Three Mile Island, and the USS *Stark*'s inability to defend itself against an Iraqi missile decades later.

Sprinkled with photos and quotes, this book provides an easy, compelling read. Frequent footnotes containing anecdotes and sidelights add interest throughout. An entertaining explanation of the lexicology of the word "Sputnik," detailed chapter notes, and a bibliography (all contained in the appendix) round out this look at "The Shock of the Century." — *Carol Ryback, associate editor*



Observing the Moon

Peter T. Wlasuk, 256 pages, Springer-Verlag, New York, 2000; ISBN 1-85233-193-3; hardcover, $39.95.

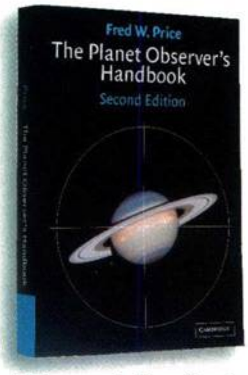
▶ *Observing the Moon* is the latest production in Patrick Moore's *Practical Astronomy Series*. Author Peter Wlasuk undertook this project with four goals in mind: to describe how the Apollo missions added to our knowledge of lunar geology; to showcase what amateur observers can accomplish with today's equipment; to correct errors of previous guidebooks; and to make lunar observing more interesting for every experience level.

The 12 chapters include a crash course in lunar geology, tips on lunar observing, and astrophotography tips for still or video cameras or CCD. *Observing the Moon* also contains a glossary of lunar terminology, a selected bibliography, sample lunar observing forms, and an accompanying CD-ROM.

The CD-ROM (produced by amateur Eric Douglass) contains an atlas of lunar features as well as sample observing forms, a selected lunar bibliography, and resources for the lunar observer. Many of the illustrations were contributed by members of the American Lunar Society.

Professor Wlasuk accomplishes all four of his goals. The volume is geared for the novice as well as the advanced observer. Wlasuk's easy, conversational tone explains lunar motion and geology. Many of the illustrations were provided by amateur observers to show readers what beginners can accomplish with basic equipment.

Although *Observing the Moon* delivers what it promises, it would have been even better with more diagrams for novice observers in the chapter on lunar motion, as well as specific maps in the chapters featuring each lunar quadrant. Other than that, Wlasuk produced a well-researched, readable work suitable for avid moon gazers. — *Robert G. Levitt, Washington University*



The Planet Observer's Handbook 2nd Edition

Fred W. Price, 429 pages, Cambridge University Press, New York, 2000; ISBN 0-521-78981-8; paperback, $29.95.

▶ Fred W. Price, a biology and biochemistry professor at State University College in Buffalo, New York, turned his passion for astronomy into a useful tool for planetary observers. He begins with an introduction to the solar system, orbital motion, and the celestial sphere, and goes on to discuss the various types of telescopes, eyepieces, and other equipment.

This handbook highlights key planetary features for observers, including a valuable collection of historical

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visual observations. More than 200 black-and-white drawings and photos illustrate the book. Although many of the line diagrams have a quaint, hand-drawn look to them, their message is perfectly clear.

Take the title literally — Price discusses the planets in great detail, and outlines the possibilities for observing asteroids, but doesn't mention studying the sun, moon, meteors, or comets. He briefly describes stellar occultation studies and photoelectric photometry, but not spectroscopy. Yet *The Planet Observer's Handbook* contains many practical details on telescopic accessories, as well as tips on general telescope maintenance.

While primarily an observing manual, this handbook covers some spacecraft discoveries as well. In a few places, the current research on the planets is very up-to-date. (For example, the recent spectroscopic discovery of chemical clouds on Saturn's moon, Titan, advanced the hypothesis of a methane-based weather system cycle.)

But other "latest findings" are more than a decade old. When the latest work on Venus is from the Pioneer Venus Orbiter (circa 1978) but no mention of the Magellan radar mapper is found, it negates the book's cover claim of "carefully updated" with the "latest spacecraft research."

The patchy effort in updating is most apparent in the chapter on astrophotography — which boasts "all the latest information on CCD and video imaging." The CCD section makes little distinction between video and digital CCD imaging. The book's failure to describe CCD equipment and techniques, coupled with the uninspiring images in this chapter, is an injustice to the magnificent results that many amateurs now routinely obtain and publish.

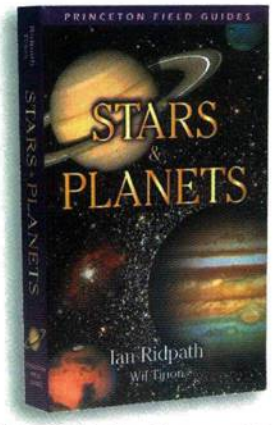
In fact, the handbook has an overall archaic tone. And, Price's disdain for computers becomes quite clear when he makes no mention whatsoever of the tremendous array of resources available on the Internet. Also, although various telescope mounts are discussed, "go-to" computerized mounts are not. (Yet the book makes little effort to explain how an observer might find Uranus in the night sky.)

In summary, *The Planet Observer's Handbook* — evidently written for a classical amateur by a classical amateur — is perfect for an observer wishing to study the planets without using equipment. Amateurs who are already proficient in CCD or video imaging will find plenty of useful historical background for their targets. However, newcomers to astronomy who hope to make digital images of the planets will be disappointed.

The Planet Observer's Handbook is a valuable tool for planetary observers, but is not necessarily a complete guide. *— Ralph D. Lorenz is a Senior Research Associate at the Lunar and Planetary Lab, University of Arizona, and co-author (with Jacqueline Mitton) of* Lifting Titan's Veil, *due for publication in 2002.*

Stars and Planets

Ian Ridpath; illustrated by Wil Tirion, 400 pages, Princeton University Press, Princeton, New Jersey, 2001; ISBN 0-691-08913-2; paperback, $19.95.



A Field Guide to the Stars and Planets, Fourth Edition

Jay M. Pasachoff; maps and charts by Wil Tirion, 578 pages, Houghton-Mifflin, Boston, 2000; ISBN 0-395-93431-1; paperback, $19.

These nearly-interchangable field guides — published by Princeton Field Guides and Peterson Field Guides, respectively — contain virtually the same information at the same high level of quality. The handy size, copious illustrations, maps, and charts, as well as the latest in astrophotography throughout each, practically beg astronomers to take them along to star parties.

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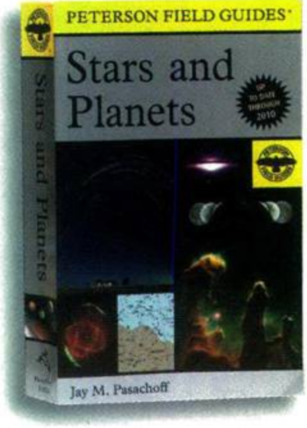

stars in the Northern and Southern hemispheres, as well as in-depth observing tips for the 88 constellations, consume more than half of Section I of the Princeton guide. Section II includes text on planets, stars, and equipment, and features photos and drawings identifying areas of interest on the moon.

Pasachoff sprinkles illustrations, charts and photos in dedicated chapters throughout his Peterson guide. Monthly star maps, deep-sky observing techniques, and plenty of basic astronomy and equipment information share space with an appendix, glossary, and bibliography that furnish readers with further astronomical tidbits.

At first blush, only star chart color and placement account for any diffference between the two field guides. On closer inspection, readers will discover that Ridpath's Princeton Guide includes information good until 2005, but that Pasachoff's includes information valid through the end of 2010. However, either guide works just fine for all levels of amateur observers. — *C.R.*

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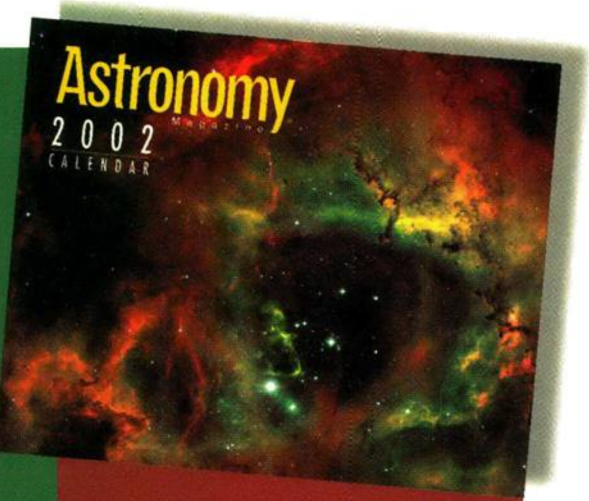

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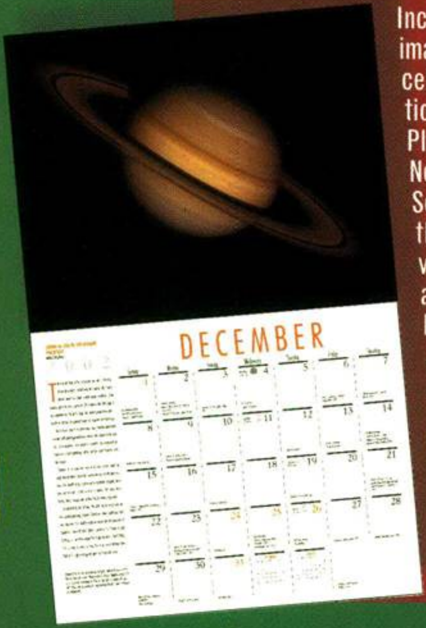

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Franklin Park, Virginia. Hosted by the Northern Virginia Astronomy Club. 4 P.M.–midnight. Contact Jeff Cook, (703) 524–5333; e-mail, jeff@cookstudios.com; website, www.novac.com/gaze.

SEPTEMBER 22

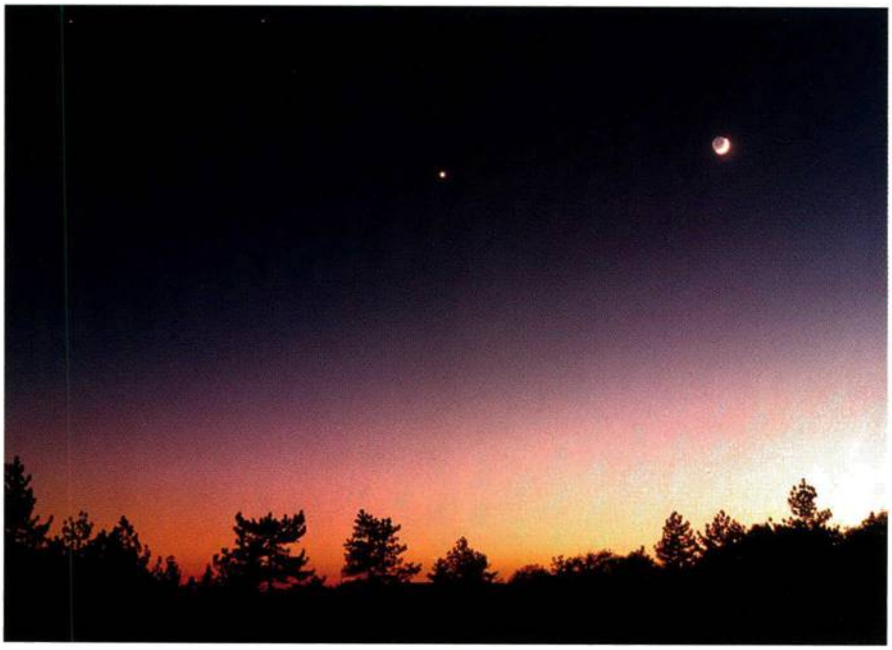
Scope Out

Cincinnati Observatory Center, Cincinnati, Ohio. Contact the Cincinnati Observatory Center, 3489 Observatory Place, Cincinnati, OH 45208; (513) 321–5186; website, www.cincinnatiobservatory.org.

SEPTEMBER 22, OCTOBER 26

Shreveport Star Party

Ralph A. Worley Observatory, south of Shreveport, Louisiana. Contact Cran Lucas, (318) 797–1524; e-mail, clucas@softdisk.com; website, http://www. lsus.edu/nonprofit/sbas/.



Chris Cook

The crescent moon, Venus, Mars, and Antares are suspended in deep twilight over a pine forest at Mt. Laguna, California.

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OCTOBER 16–20

Twin Lakes Star Party

Land Between the Lakes National Recreational Area, western Kentucky. Sponsored by the West Kentucky Amateur Astronomers. For more information, contact Ross Workman, (270) 797–8959; e-mail, planetman@vci.net; website, http://www.wkaa.net.

OCTOBER 17–21

Deep South Regional Stargaze

Percy Quin State Park, near McComb, Mississippi. For more information, contact Barry Simon, 842 Crystal Street, New Orleans, LA 70124; (504) 283–7592; e-mail, bsimon615@aol.com.

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Astronomy Camp for Beginning Adults

Mt. Lemmon and Mt. Bigelow Observatories, University of Arizona, Tucson, Arizona. Contact Don McCarthy, 933 North Cherry Avenue, Tucson, AZ 85721; (520) 621–4079; e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astrocamp.

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Colorado Astronomy Day

Chamberlin Observatory, Observatory Park, University of Denver Campus, Colorado. Contact Steve Solon, (303) 932–7613; e-mail, galaxyshots@compuserve.com, or Larry Brooks at (303) 986–5255; e-mail, LBrooks100@aol.com.

OCTOBER 28

Blue Ridge Parkway Regional Stargaze, Part II

Julian Price Park Picnic Area, Julian Price Park on the Blue Ridge Parkway, just south of Blowing Rock, North Carolina. For more information, contact Greg Kirby, (828) 396–7656; e-mail, lmocvac@twave.net; or view the website, http://users.twave.net/jafowiz/brprs.htm. A

CONTACT

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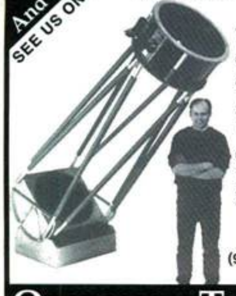

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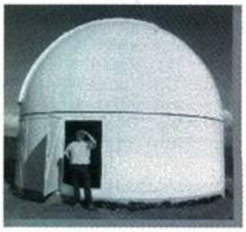

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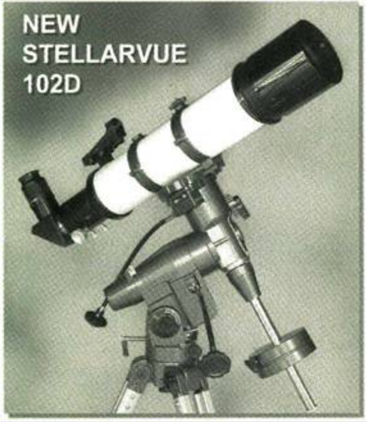

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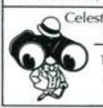

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ASM Products 101
Adorama 94, 95
Analytical Scientific 103
Arctic Odysseys 104
Astro Haven 103
Astro-Physics 104
Astronomical Adventures 102
Astronomics 32, 33
Astronomy.com 97, 100
Astronomy Calendar 97
Astronomy Magazine 93, 105
Astronomyquest.com 14
Astrotec 102
Atomic Time 31
Beigle/Bryant Engineering 103
Bennett Book Advertising 31
Berger Bros. Camera 104
Bethany Sciences 105
Camera Bug 102
Celestron International 16, 17, 18, 19
Centre for Astronomy 21
Cruise Holidays 101
Discovery Telescopes, Inc 31
Eclipse 2002 Tour to Australia 86
Eclipse Edge Expeditions 91
Edmund Scientific 14
Enchanted Skies Star Party 21
Equatorial Platforms 102
Explore the Universe 2002 96
Focus Camera 54, 55
Fujinon 99
Glatter, Howard 77
Hardin Optical Co. 14, 101
Harrison Scientific Instruments, Ltd. 104
Harvard University Press 86
Inside Systems GmbH 101
Internet Telescope Exchange 104
Into the Wind/The Kite Source 104
JMB, Inc. 77
Jim's Mobile Industries 15
Kendrick Astro Instruments 99
Kitt Peak National Observatory 21
Learning Technologies, Inc. 102
Let's Talk Stars 86
Lumicon 23
Marketplace Pages 101, 102, 103, 104, 105
Meade Instruments Corp. 2, 3, 7, 8, 9, 10, 11, 114
Minerva Press 103
Mountain Skies Astronomical Society 102
New England Meteoritical 105
New Mexico Skies 102
Newport Glass Works 101
Nisur Systems 102
Northern Lights Tour 106
Novaspace 104
Observatory Inc., The 102
Obsession Telescopes 102
Oceanside Photo & Telescope 77
Optical Guidance Systems 105
Orion Telescopes & Binoculars 66, 67, 113
Pegasus Optics 103
Peterson Engineering 101, 103
Pocono West Optics 13
Rainbow Symphony 101
Rivers Camera Shop 96
SAC Imaging Systems 104
SCS Astro 99
Science Connection, Inc. 101
Scope City 29
Scope Tronix 21
Shutan Camera & Video 87
Sirius Observatories 102
Sky Watchers Inn 101
Skytent International 103
Software Bisque 25
Star Tek Industries 103
Starmaster Portable Telescope 102
Starsafaris.com 89
Stellar Endeavors 103
Stellarvue 103
T &T Binocular Mounts & Beyond LLC 99
Teaching Company, The 27
Technical Innovations 14
Terlingua Ranch Lodge 101
Travel Quest 104
Travel Wizard 103
Tropical Sails 104
University Optics, Inc. 103
Web Site Directory 106
Wolf Camera 102
Woodland Hills Photo Images 91
www.bigbinoculars.com 104
Yes Watch 29

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Astronomy Magazine

Alaskan aurora photograph by Mike O'Leary

A38443ad

AFRICAN ADVENTURES

Eclipse Memories

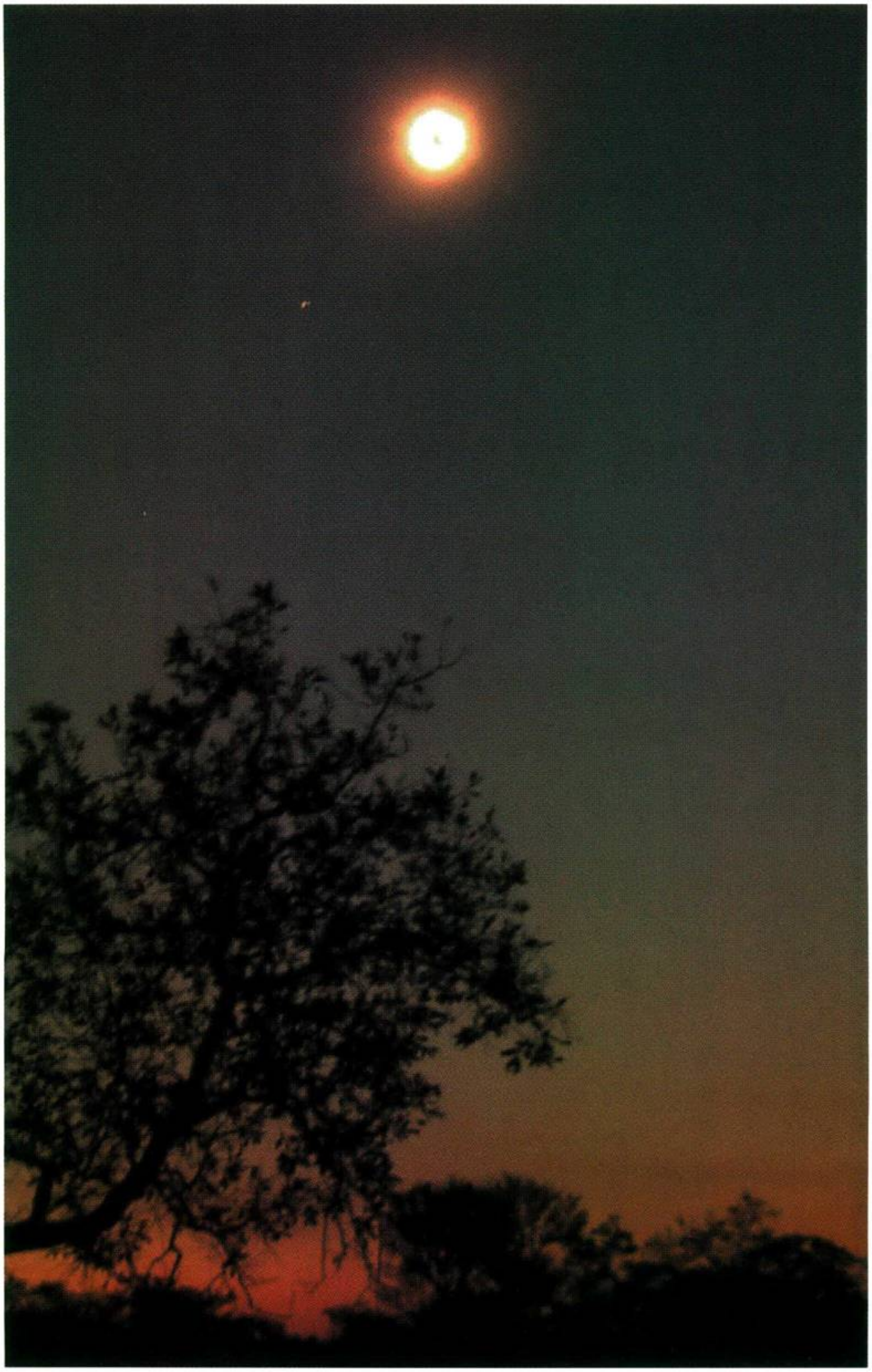
▶ I knew that traveling to Africa to view the total solar eclipse of June 21, 2001 would be a life-altering experience. I knew I would never forget the exotic animal species, the beautiful landscape, or the sight of day turning to night in the middle of the afternoon.

But I was wrong to think that the most exciting part of the trip to Zimbabwe would be Victoria Falls. Although a mile-long falls three times the height of Niagara is impressive, I was wrong to think that the falls would move me more than the animals.

And I was wrong to think that the animals — elephants, lions, impala, rhinos, hippos, and others — would touch me more than the eclipse.

And most of all, I was wrong to think that the eclipse, with its stars-in-the-afternoon, corona ringing the black moon, and solar flares rising from behind the lunar surface, would change me more than the people of Zimbabwe.

We traveled three hours outside of the capital city of Harare to the little village of Rushinga to have the opportunity to stand directly in the moon's shadow. We rode in a convoy of three luxury buses down "wide tar" roads, passing only a few dilapidated buses and even fewer cars. Zimbabwe is in the grip of a severe gas shortage due to lack of foreign currency, so very few people can afford mech-



Corona and Jupiter

ERIC FLESCHER

(35mm lens at f/3, Kodak digital camera, taken June 21, 2001, from Zambia, Africa) anized transportation. We saw people walking down these country roads going to or from their "traditional" circular homes of sticks and mud walls, dung polished floors, and thatched roofs. As we entered Rushinga, people came out of these homes to wave and smile at us.

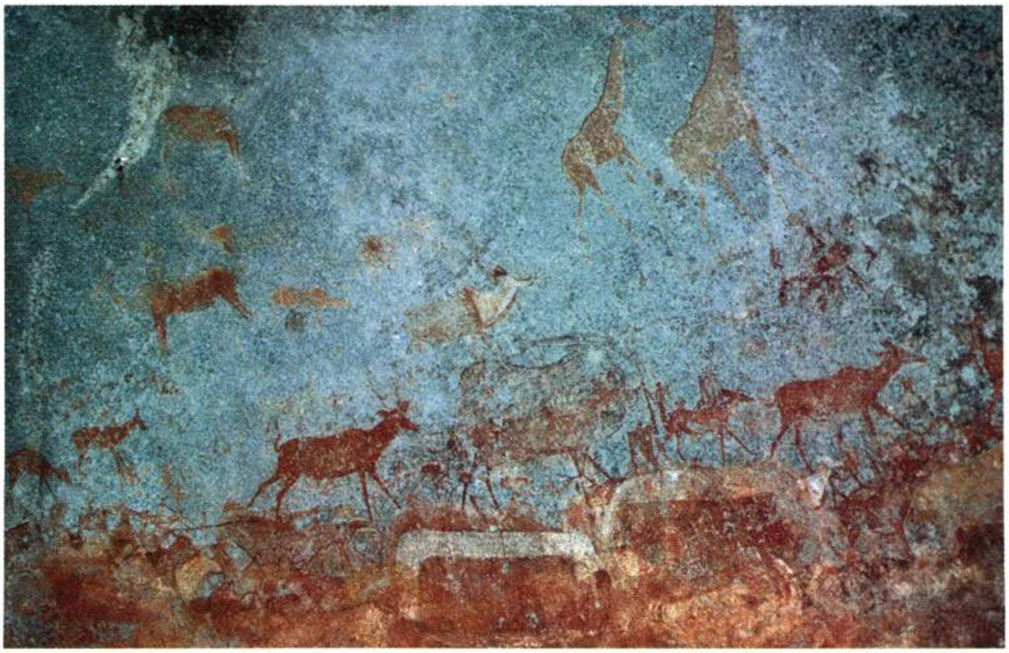
The travel agent for our *Astronomy* magazine tour group had asked the local chief if we could use the grass landing strip as our ground zero to set up our equipment. As a gesture of appreciation, our group collected money to donate to the village for the local clinic. With this money, the village bought sheets (something the beds never had), equipment to help the two nurses, and paint for the clinic's three small buildings. (These two nurses see 300 patients daily and treat TB, AIDS, malaria, and many other diseases. If patients need to be hospitalized, they have to make their own way to the distant hospital.)

We were likely the largest group of tourists most of the village inhabitants had ever seen, making us something of a curiosity. After only a few minutes at the airfield, we heard singing coming from the village. About sixty 10 to 14-year-old-girls were marching in formation, dressed in their best white shirts, skirts, socks, and sneakers. They were singing to welcome us to their village!

We then walked back to the clinic, where the villagers held a ceremony to thank us for our help and to show off their newly painted clinic. There must have been a thousand children looking at us quietly as we watched the presenta-

The Stone Ruins at Great Zimbabwe

EVELYN TALCOTT



Bushman Cave Art
Matopos, Zimbabwe

BECKY TALCOTT

Partial Eclipse from Gorchs, Argentina

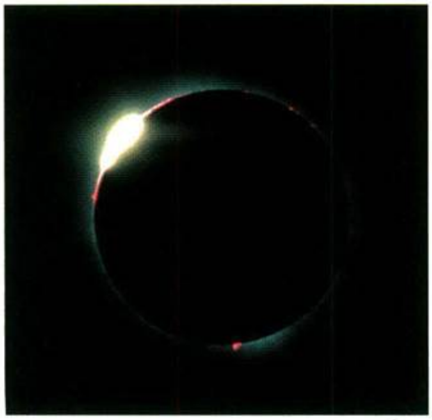
HERNÁN TOLOSA

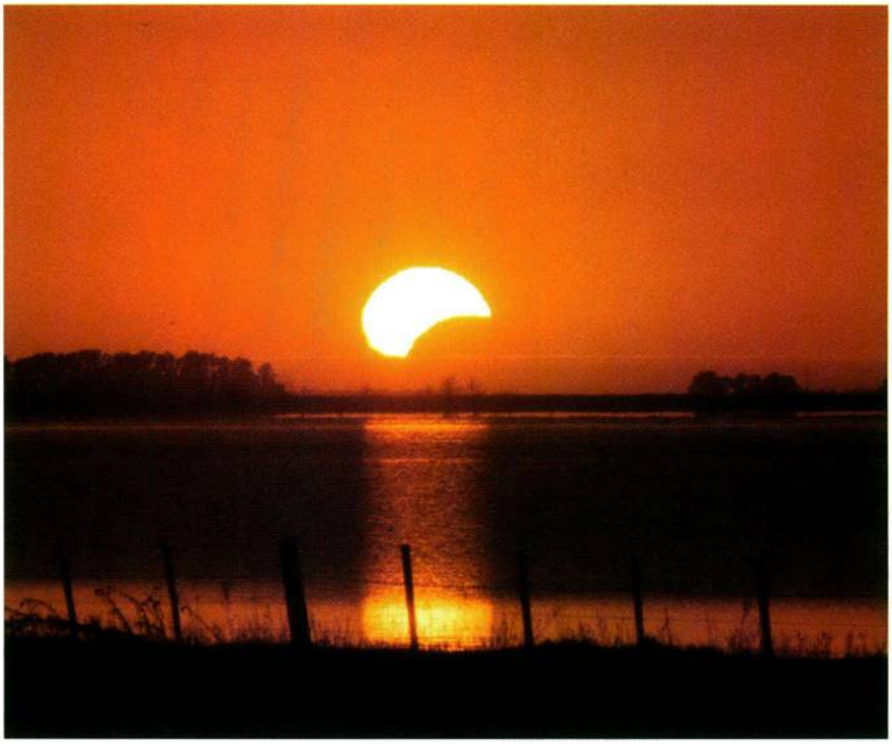
(300mm lens at f/22, Kodak Ultra 400 film, taken June 21, 2001, near the Salado River)

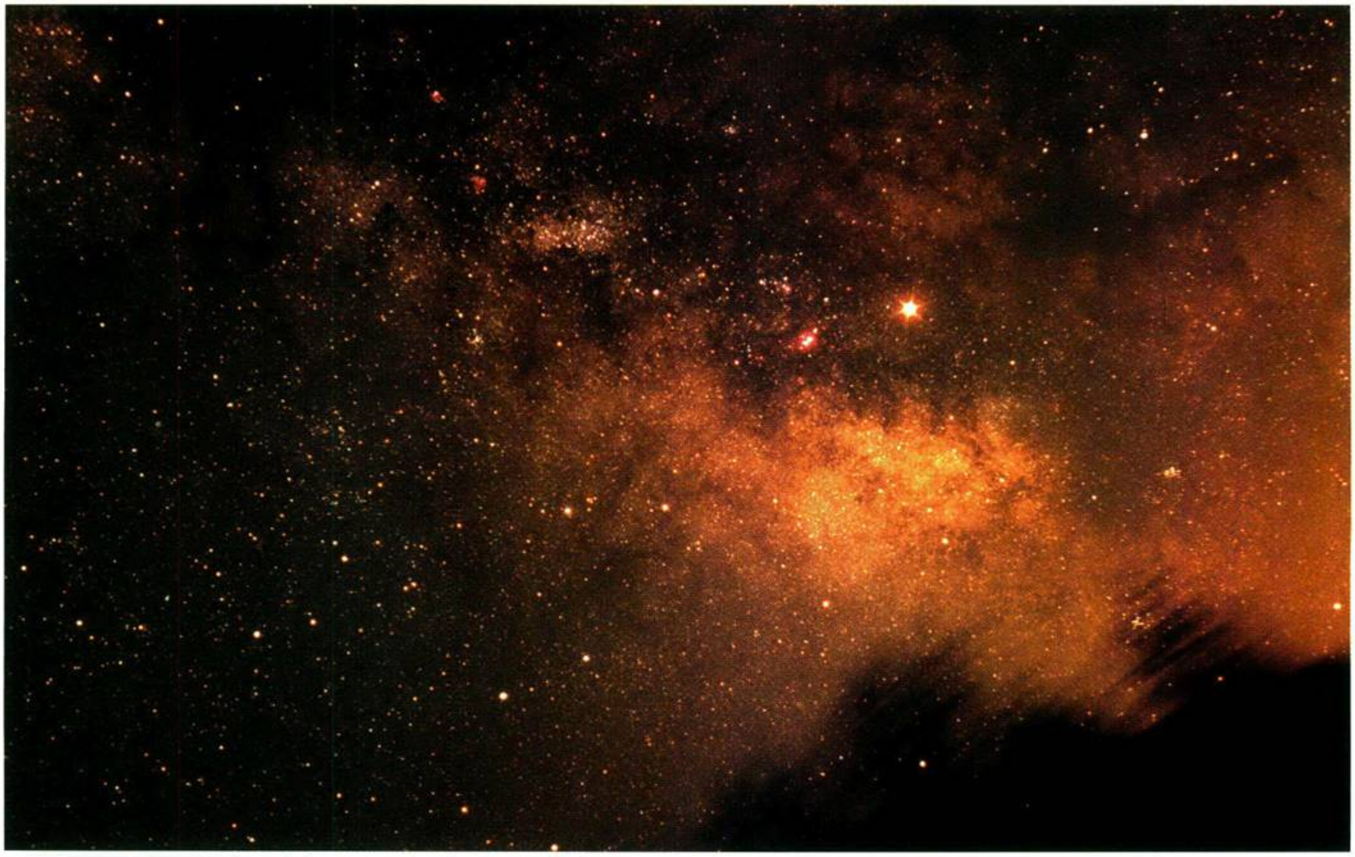
Total Eclipse from Zambia

JAN A. SPEETS

(500mm lens at f/8, Kodak Gold 100 film, taken June 21, 2001)







Mars in Sagittarius

FRÉDÉRIC CARON

(50mm lens at f/4, Fuji NHG II film, composite of two nine-minute exposures taken May 20, 2001) tion. They were all happy to see us, and full of curiosity and hope. "Could I be your pen pal?" "When will you come back?"

Later, back at the airstrip, we milled about watching the moon meet the sun. Several hundred villagers were lined up along the fence. I did not know whether they were there out of curiosity or if they thought that they had to be close to our spot in order to see the eclipse. Despite the hundreds of pairs of protective glasses we had distributed to view the partial phases of the eclipse, many did not have a pair, and I had the impression they thought they would miss the eclipse without them. I walked along the fence, showing the people of the village how to see the image of the eclipsing sun on the ground through small openings made with their hands and assured them they would not need glasses when the time came.

The eclipse was glorious. A black disk surrounded by the sun's corona is a sight to behold. Everyone cheered; no one was unmoved. But I was more moved, more touched, and more changed by the people of Zimbabwe than by their falls, their animals, or their eclipse. ■

Donato A. Viggiano is a plastic surgeon and avid astronomer in Florida.

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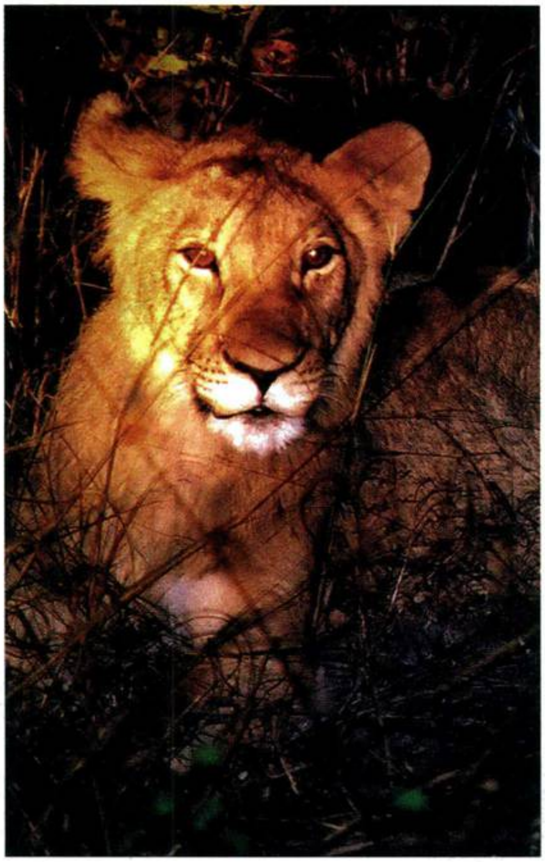
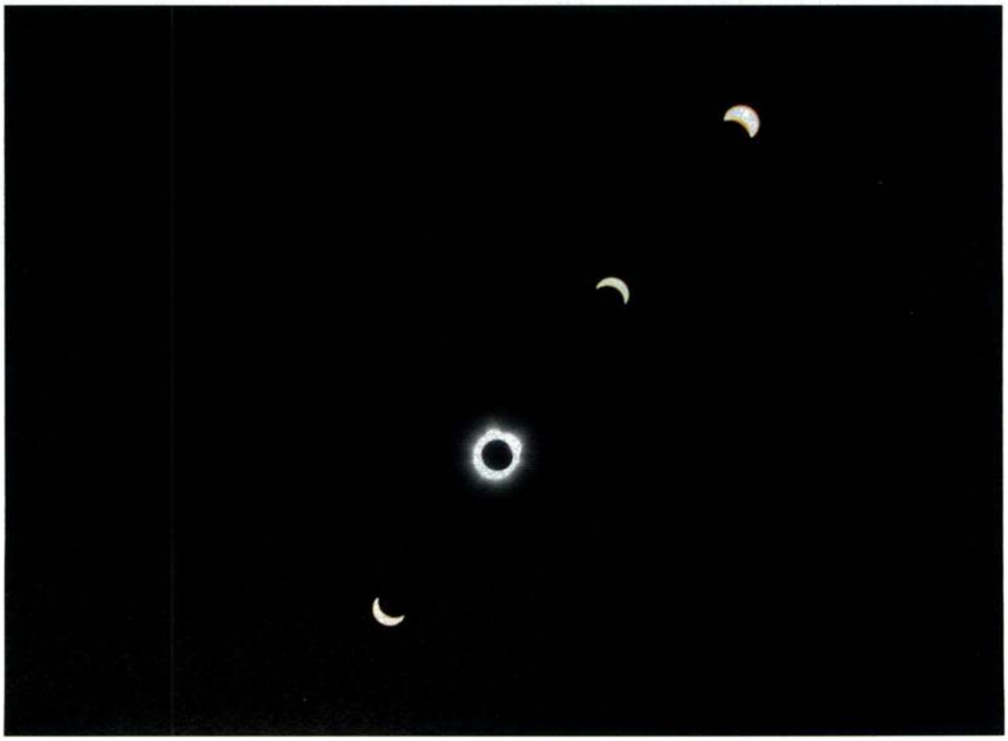


Lion in Hwange National Park, Zimbabwe

DAVE BUCHLA

Elephants Crossing Lake Kariba, near Matusadona National Park, Zimbabwe

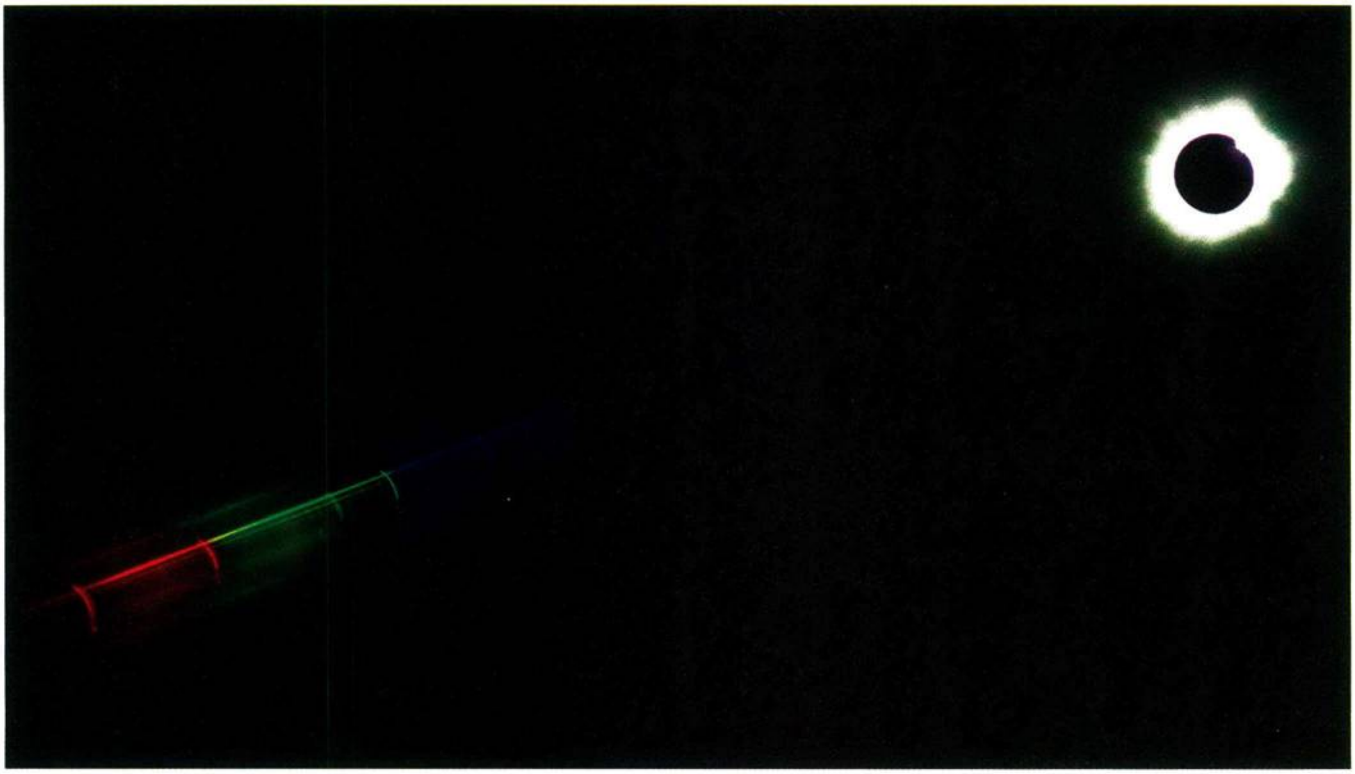
WILLIS GREINER



Eclipse Composite

DAVID BARSTOW

(120mm lens, composite of four exposures taken over one hour on June 21, 2001, from Zambia, Africa)



Top: Coronal Spectrum with Eclipse

ROBERT B. SLOBINS

(150mm lens at f/4, Fuji NPS film, taken June 21, 2001, from Zambia, Africa)

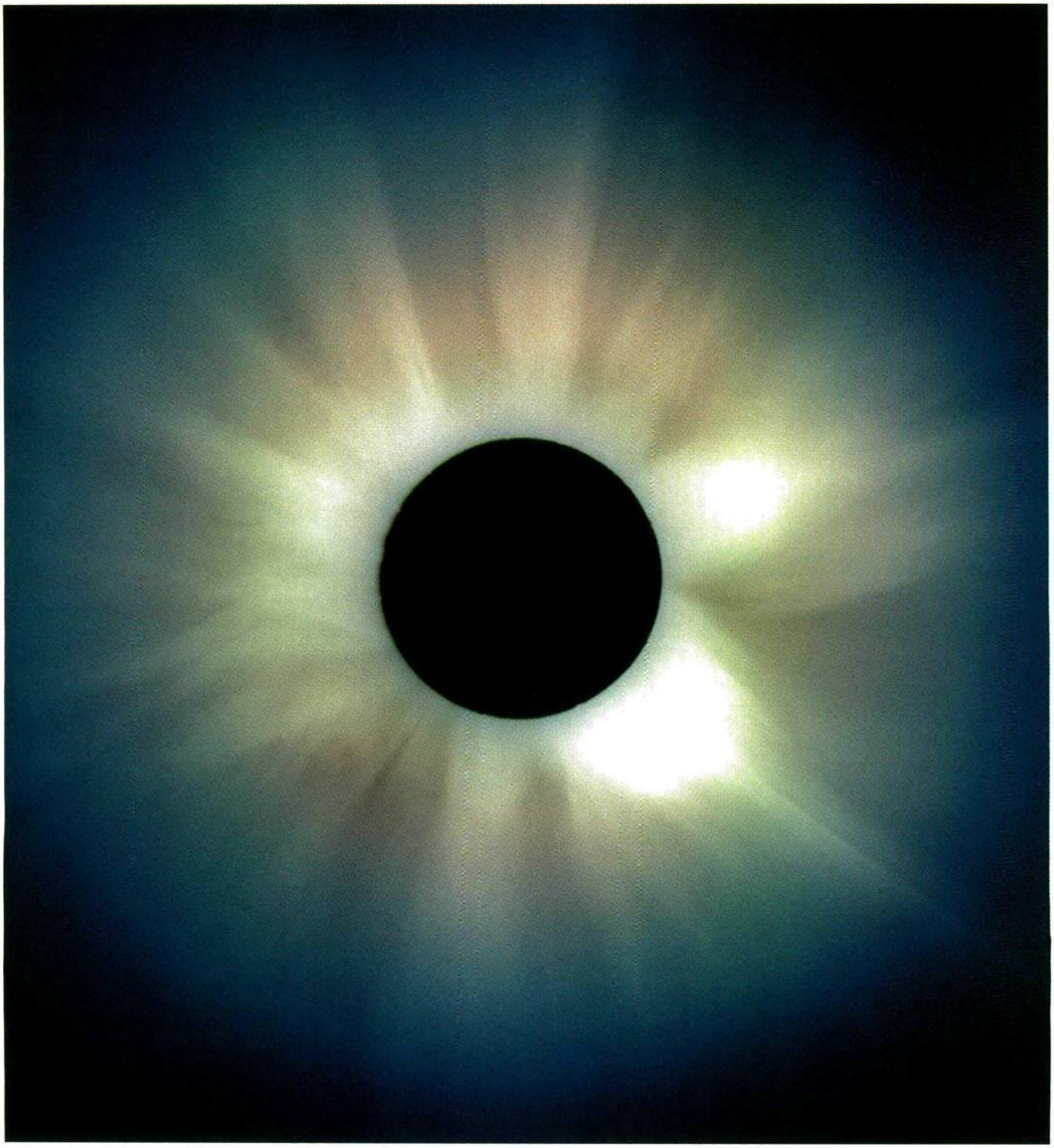
Bottom: Sunset over Lake Kariba, Matusadona National Park, Zimbabwe

WILLIS GREINER

Children Gathered in Rushinga, Zimbabwe for Eclipse Celebration

PETER SUTTER

This month's best astrophoto



Solar Corona

ALBERTO LEVY

(80mm refractor at f/14.3, Fuji NPC-160 ASA film, three-second exposure)

This stunning image of the corona was taken in Lusaka, Zambia, with a vignetting disk in the light path of the telescope.

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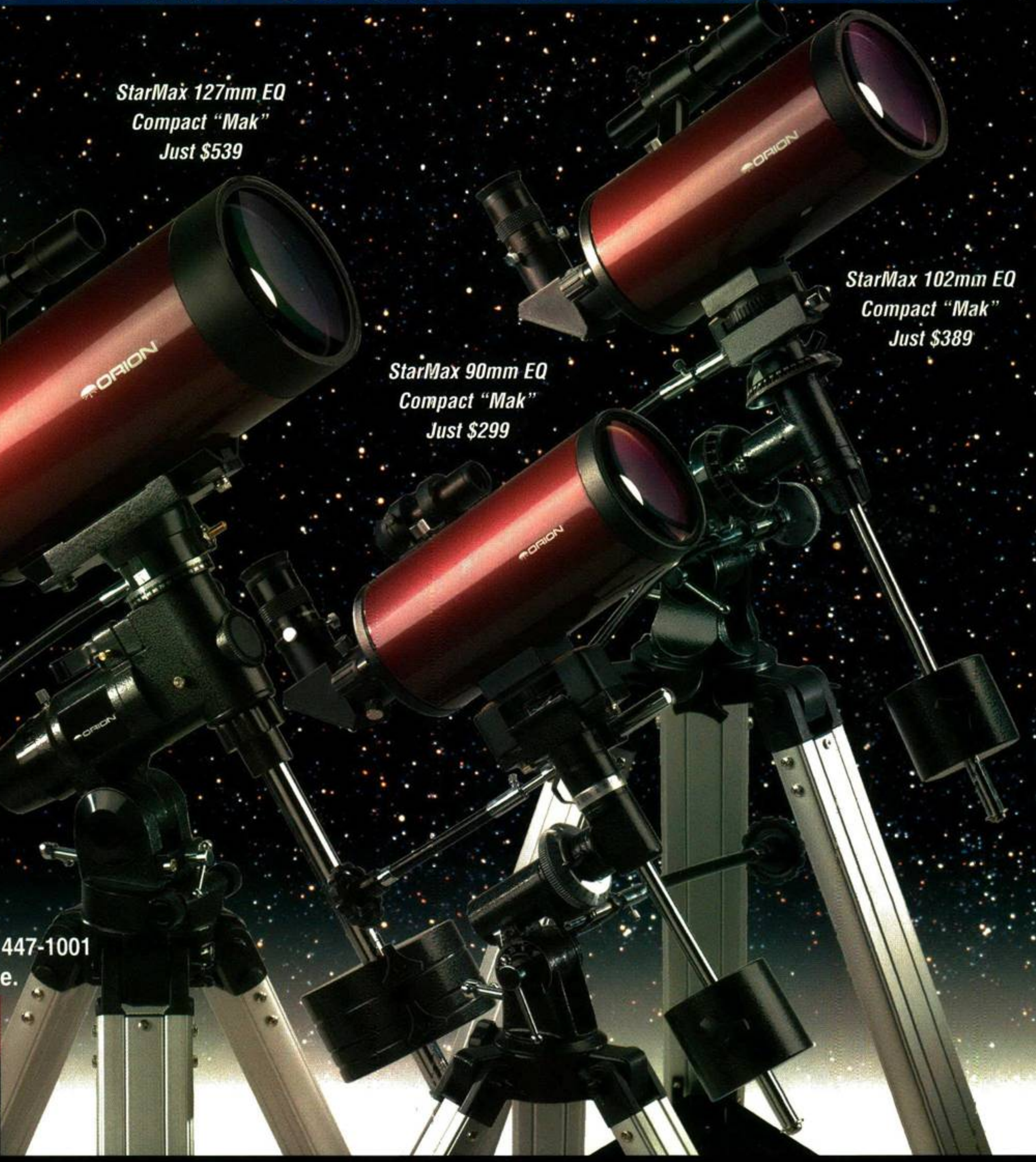
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